Description and Operating Manual

MP MASTER
MA29280

Level Generator

PS-15

Frequency range 50 Hz to 10 MHz

BN 0954/00.82

LEVEL GENERATOR PS-15
Frequency range 50 Hz to 10 MHz

Description
and operating manual BN 954, Series B...

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INTRODUCTION

The PS-15 Level Generator provides a signal source for measurements in the following areas of application: unbalanced and balanced FDM communications systems, baseband frequency level radio-link- and satellite systems with up to 1872 channels, and single voice-grade and sound-program-channels.

The PS-15 is compact, robust, easy to use, and can be operated independently of a.c. mains; it is thus ideal for use as a portable maintenance and in-service test instrument for postal systems, railways, and public utility companies providing energy. It is also a valuable tool for research and development, production, and testing, due to its high degree of accuracy and spectral purity.

The highest standards required for FDM measuring instruments are met by the PS-15, through the use of modern integrated circuits and microprocessor technology.

The frequency generator used in the PS-15 is a synthesiser. As a result, the send frequency can be set accurately and rapidly using a numerical keypad. The setting resolution is 1 Hz throughout the entire frequency range of the instrument, 50 Hz to 10 MHz. The keypad may also be used to set a frequency step which corresponds, for example, to the frequency separation between channels. The frequency can then be changed by this amount manually or semi-automatically.

The send level is set in the same way as the frequency; the level chosen is shown on a 3 digit display with a maximum resolution of 0.1 dB. The send level can be varied over a wide range of voltage- and power-levels, depending on the setting of the fine level control ($\pm$0.1 dB) and the output impedance. The output level can be "soft" switched (on or off) to facilitate measurements on systems actually in use.

The output level is held constant by an internal AGC amplifier. It is possible to eliminate losses and matching errors, which occur when long leads are used, by setting up a control loop in which the setting voltage of the EPM-1 Milliwatt Power Meter (which acts as an ALC amplifier) is fed into the control voltage input of the PS-15. Using this method, the PS-15 can be used as a reference a.c. level source of 0 dBm or 0 dB.

The output impedance of the coaxial output is 75 Ω. For tests on balanced systems, a balanced output with switchable output impedances is available.

The PS-15 can be used in conjunction with a SPM-15 Selective Level Meter to form a complete Level Measuring Setup. If the instruments are situated close together, the PS-15 send frequency can be synchronised with the SPM-15 by using two control cables.

When not connected in this way, they can be set independently to different frequencies, which is often necessary when measuring distortion or crosstalk between adjacent channels.

Power supply for the PS-15 is from a.c. mains. For complete portability, the BAZ-15 Battery Pack (BN 955/00.01) is available as an option, which is easily fitted to the back panel of the instrument. The BAZ-15 contains rechargeable batteries, which are charged by a circuit in the Level Generator.

The <IEC 625> Interface Board, BN 955/00.03, has the same dimensions as the battery pack, and can be fitted instead of it to allow remote control of all important instrument functions, and installation as part of an automatic measuring system.

1 SPECIFICATIONS

1.1 FREQUENCY

1.1.1 FREQUENCY RANGE

Version	BN 954/01	BN 954/02	Frequency range
coaxial output	75 Ω	75 Ω	50 Hz to 10 MHz
balanced output	124/150 Ω	124 Ω	6 kHz to 10 MHz
	600 Ω	135/600 Ω	50 Hz to 620 kHz

1.1.2 FREQUENCY INDICATOR ..... 7 digit LED display

Resolution ..... 1 Hz

1.1.3 FREQUENCY SETTING

Digital via keyboard, also in discrete steps using the direction keys;
smallest increment (step-width set using keypad) ..... 1 Hz

1.1.4 ERROR LIMITS, SEND FREQUENCY ..... $\pm 3 \times 10^{-6}$

This limit is valid under the rated operating conditions for the influence quantities as defined in Section 1.6. It includes ageing of 1 year.

1.2 SEND LEVEL

1.2.1 SIGNAL SHAPE ..... sinusoidal

1.2.2 LEVEL INDICATOR

RMS value, 3 digit LED indicator with sign, resolution ..... 0.1 dB
Power level (dBm) referred to ..... 1 mW
Voltage level (dB) referred to ..... 0.7746 V

1.2.3 LEVEL SETTING

Digital via keypad, also in discrete steps using the direction keys;
smallest increment ..... 0.1 dB
Fine control via knob, range ..... $\pm$0.1 dB
"Soft" blanking of send level using pushbutton;
Blanking attenuation ..... $\geq$ 80 dB

1.2.4 LEVEL RANGE

Output		Power level	Voltage level
coaxial	Z_o = 75 Ω	-60.9 to +19 dBm	-69.9 to +10 dB
balanced[1]	Z_o = 124 Ω	-63.1 to +16.8 dBm	-69.9 to +10 dB
	Z_o = 150 Ω	-63.9 to +16 dBm	-69.9 to +10 dB
balanced [2]	Z_o = 600 Ω $Z_{out} = Z_o$	-69.9 to +10 dBm	-69.9 to +10 dB
	Z_o = 600 Ω Z_{out} = 0	-63.9 to +16 dBm	-63.9 to +16 dB

1) BN 954/02: Z_o = 124 Ω only

2) BN 954/02: Z_o = 600, 135, 0 Ω, Level range for Z_o = 135 Ω: -63.4 to +16.4 dBm (-69.9 to +10 dB)

1.2.5 SEND LEVEL ERROR LIMITS

Unless otherwise stated, the error limits are valid under the rated operating conditions for the influence quantities, as defined in Section 1.6

1.2.5.1 Error limits, 0 dBm (0 dB) output level at:

f = 10 kHz (100 kHz for Z_o = 124 Ω and 150 Ω),
$Z_{out} = Z_L = Z_o$ or Z_{out} = 0 and $Z_L = Z_o$, T = 23 ± 3°C ..... ±0.1 dB

1.2.5.2 Max. error on set output level: ..... ±0.1 dB

1.2.5.3 Frequency response of send level

for $Z_{out} = Z_L = Z_o$ or Z_{out} = 0, $Z_L = Z_o$, referred to
f = 10 kHz (Z_o = 75 Ω, 600 Ω) or f = 100 kHz (Z_o = 124 Ω, 150 Ω), T = 23 ±3°C:

Output		Error limits (dB)				
coaxial Z_o = 75 Ω		±0.1				
balanced[1], Z_o = 124/150 Ω		-	±0.15			
balanced[2] Z_o = 600 Ω	$Z_{out} = Z_L = Z_o$	±0.2	±0.15		-	
	Z_{out} = 0 $Z_L = Z_o$	±0.2	±0.15	±0.5	-	
		50 Hz	200 Hz	6 kHz	100 kHz	620 kHz 10 MHz

1) BN 954/02: Z_o = 124 Ω only

2) BN 954/02: Z = 135, 600 Ω

1.2.5.4 Average temperature coefficient of send level

within the rated limits of ambient temperature, referred to 23°C ..... ±0.006 dB/K

1.2.5.5 Overall Error Limits

for levels within the ranges given in 1.2.4 and within rated operating range as given in Section 1.6, with $Z_{out} = Z_L = Z_o$ or $Z_{out} = 0$, $Z_L = Z_o$

(combines the partial errors given in 1.2.5.1 to 1.2.5.4)

Output	Error limits/dB				
coaxial 75 Ω	±0.25				
balanced[1], Z_o = 124/150 Ω	–	±0.3			
balanced[2], $Z_{out} = Z_L = Z_o$	±0.4	±0.3		–	
balanced[2], $Z_{out} = 0$, $Z_L = Z_o$, Z = 600 Ω	±0.4	±0.3	±0.6	–	
	50 Hz	200 Hz	6 kHz	100 kHz	620 kHz 10 MHz

1) BN 954/02: Z_o = 124 Ω only

2) BN 954/02: Z = 135, 600 Ω

1.3 MEASUREMENT OUTPUTS

1.3.1 COAXIAL OUTPUT

No d.c. offset voltage permissible (i.e. screen tied to ground)

convertible to all common socket types ..... Versacon® 9 System

BN 954/02: Socket for plug ..... WECO 358A

Frequency range ..... 50 Hz to 10 MHz

Output impedance ..... 75 Ω

Return loss at f = 10 kHz ..... ≥ 50 dB

over total frequency range ..... ≥ 40 dB

1.3.2 BALANCED OUTPUT, FLOATING ..... 3pole CF socket

Max. permissible a.c. or d.c. voltage referred to earth, V_{rms} ..... 60 V

Generator signal balance ratio, to CCITT 0.121 ..... ≥ 40 dB

1.3.2.1 Frequency range ..... 6 kHz to 10 MHz

Output impedance, switchable ..... 124 Ω, 150 Ω

BN 954/02: 124 Ω only

Female connector for ..... WECO 372A/379A male connector

Return loss at f = 100 kHz ..... ≥ 40 dB

1.3.2.2 Frequency range ..... 50 Hz to 620 kHz

Output impedance, switchable ..... approx. 5 Ω; 600 Ω
BN 954/02: additionally 135 Ω
Female connector (135 Ω) for ..... WECO 241A male connector
Female connector (600 Ω) for ..... WECO 310 male connector
Return loss at f = 10 kHz ..... ≥ 40 dB

1.4 OUTPUT VOLTAGE SPECTRAL PURITY

at $Z_{out} = Z_L = Z_o$ or $Z_{out} = 0$, $Z_L = Z_o$

1.4.1 HARMONIC RATIO (2nd and 3rd order)

Output level ≤ 0 dB/dBm ..... ≥ 50 dB
over total level range and for f = 50 Hz to 6 MHz ..... ≥ 40 dB
over total level and frequency range ..... ≥ 34 dB

1.4.2 NON-HARMONIC SPURIOUS VOLTAGES

Frequency range 50 Hz to 10 MHz ..... ≥ 70 dB below signal level
or spurious signal level ..... ≤ -120 dB (-110 dBm)

1.4.3 NOISE

Referred to 1 Hz bandwidth,
at output level 0 dB/dBm, send frequencies ≥ 10 kHz and
at frequency offset from wanted signal of: ≥ 20 kHz ..... ≥ 120 dB
≥ 200 kHz ..... ≥ 130 dB

1.5 ADDITIONAL INPUTS AND OUTPUTS

1.5.1 EXTERNAL FREQUENCY-STANDARD INPUT[1)]

Connector ..... BNC
Frequency ..... 10 MHz
Level ..... -10 dBm to +10 dBm
Input impedance ..... 75 Ω

1.5.2 EXTERNAL TUNING FREQUENCY INPUT[1)]

Connector ..... BNC
Frequency ..... 40 to 50 MHz
Level ..... -6 dBm ± 3 dB
Input impedance ..... 75 Ω

---

1) For external tuning with SPM-15 or SPM-18/SPM-19 (up to 10 MHz)

1.5.3 EXTERNAL AMPLITUDE CONTROL CONNECTOR ..... 3 pole TF female conn.

for control of the send amplitude using EPM-1

1.5.4 REMOTE CONTROL INPUT (only with BN 955/00.03 option)

DIN IEC 625 Interface (IEEE 488 with S 834 adaptor) for control of all basic instrument functions.

Interface functions ..... SH1, AH, T6, L4, SR1, RL1, PP2, DC1, DT1, CØ

1.6 P O W E R S U P P L Y A N D A M B I E N T C O N D I T I O N S

All error limits given in the technical data above are valid immediately after switch-on, for the rated ranges of use for the influence quantities given below, unless otherwise stated.

1.6.1 POWER SUPPLY

1.6.1.1 A.C. mains operation

rated ranges of use

Selected Value	Voltage Range
110 V	96 - 121 V
117 V	103 - 129 V
127 V	112 - 141 V
220 V	193 - 242 V
227 V	199 - 250 V
237 V	208 - 261 V

A.C. mains frequency ..... 47.5 to 63 Hz

Power consumption during measurements ..... approx. 38 VA

during charging ..... approx. 35 VA

1.6.1.2 Battery operation

With built-in rechargeable batteries (Option BN 955/00.01)

Operating time ..... approx. 5 hours

Charging time ..... approx. 14 hours

Battery type ..... 12 x KR 35/62

1.6.2 SAFETY CLASS

To IEC 348 and VDE 0411 ..... Class I

1.6.3 AMBIENT CONDITIONS

Ambient temperature
Range of use ..... 0 to +50°C
Storage and transport ..... -40 to +60°C
RFI suppression to Reg. 526/1979 of the German Federal Post Office

1.7 DIMENSIONS, WEIGHT

Dimensions in mm (depth x height x width) ..... 317 x 175 x 342
Weight
PS-15 without options ..... approx. 11 kg
BAZ-15 ..... approx. 2.8 kg
<IEC 625> interface board ..... approx. 1 kg

1.8 ORDERING INFORMATION

PS-15 Level Generator*	BN 954/01
PS-15 Level Generator with WECO-connectors	BN 954/02
Options (at extra cost)	
BAZ-15 Rechargeable Battery Pack	BN 955/00.01
<IEC 625> Interface Board	BN 955/00.03
with IEC 625/IEEE 488 adaptor (S 834)	
135 Ω impedance instead of 150 Ω (for BN 954/01)	BN 954/00.21
Accessories (at extra cost)	
EPM-1 Milliwatt Power Meter[1]: dc; 10 Hz to 300 MHz	BN 564/00
Connecting cables for <IEC 625> Interface Bus	
120 cm	K 343
200 cm	K 344
SD-940 Protective covers (1 set)	BN 960/00.02
19" Rack mounting conversion kit	BN 4502/00.16

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* Supplied with 75 Ω basic Versacon® 9 connector fitted with BNC adaptor.
For other adaptors, see the Versacon® 9 Specification Sheet and order chosen type when ordering instrument.

1) For technical specifications see EPM-1 Specification Sheet.

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2 TECHNICAL FEATURES

The PS-15 Level Generator basically comprises the following modules: frequency- and level-generators, microprocessor, controls and indicators, and power supply. The simplified block diagram is used as the basis of the more detailed explanations of instrument functions which are given in the following sections.

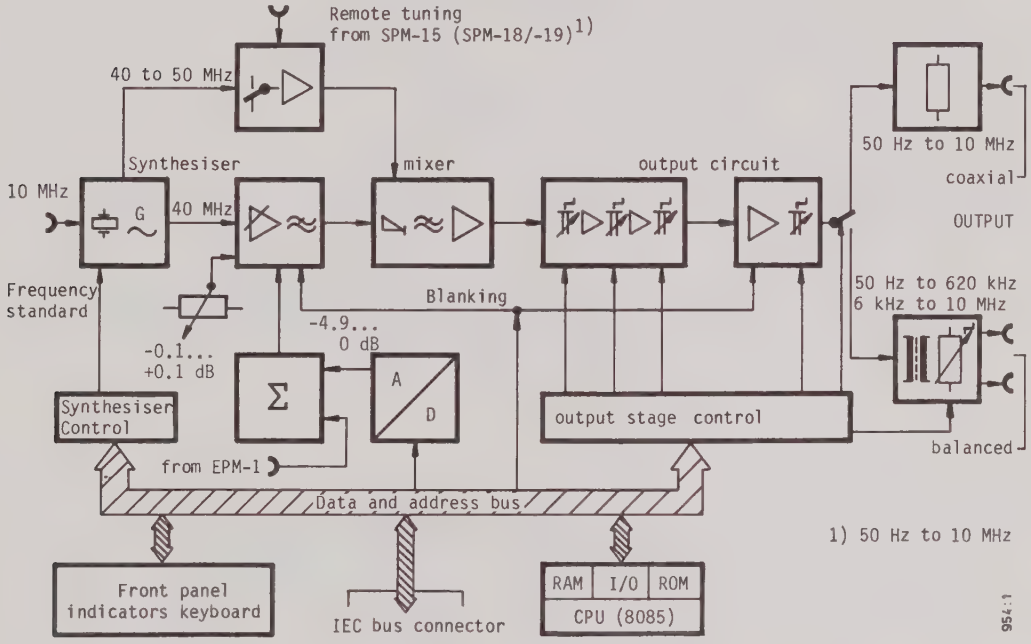


Figure 2-1 Simplified block diagram, PS-15 Level Generator

2.1 FREQUENCY AND LEVEL GENERATORS

The Level Generator operates on the beat frequency principle, the output frequency resulting from the fixed internal frequency of 40 MHz and the variable carrier frequency of 40 to 50 MHz. The fixed frequency is generated by a voltage-controlled crystal oscillator, locked to a standard frequency of 10 MHz, which is either provided by the synthesiser or by an external oscillator. Since the fixed frequency corresponds to the first intermediate frequency of the SPM-15 Level Meter, the generator and receiver can be tuned synchronously, using the tuning oscillator in the SPM-15. In the frequency range up to 10 MHz, synchronous tuning is also possible using the SPM-18 or SPM-19 Level Meters.

The fixed internal frequency of 40 MHz is passed through an AGC amplifier which maintains a constant output amplitude. By varying the regulating voltage of the amplifier, the output can be altered in steps of 0.1 dB by up to 5 dB. The voltage for this is derived from a D to A converter. The send level may also be changed by ±0.1 dB using the "FINE" level control.

The fixed internal frequency is passed through a low-pass filter to the mixer where it is converted to the output frequency (range 50 Hz to 10 MHz) with the aid of the carrier frequency from the synthesiser or the external source. A subsequent 10 MHz low-pass filter suppresses the upper sideband, harmonics, and residual components. The signal then passes through a pre-amplifier and attenuator chain before the driver and output amplifier stages bring it to its maximum value. The output signal is taken from the low impedance output of the output switch section to the output stage. Either balanced or coaxial (unbalanced) outputs can be selected. All the stages in the output signal path feature very flat frequency response; hence an almost constant output level can be maintained over the entire frequency range.

2.2 BLANKING AND EXTERNAL CONTROL OF SEND LEVEL

The send level can be "soft"-switched (on or off) in the 40 MHz AGC amplifier. To achieve a high degree of blanking attenuation, the attenuator in the output amplifier is fully switched-in when the signal level has stopped decreasing. The selected output impedance is maintained. Switch-on and switch-off times are approx. 60 ms.

The AGC amplifier can also be controlled by an external regulating voltage. An external AGC circuit can be set up using an EPM-1 Milliwatt Power Meter to control the output level, allowing, for example, corrections for the attenuation in long feeder cables, or for variations in input level to be made. The PS-15 can also be used in this mode as an 0 dB/dBm reference-level generator.

2.3 MICROPROCESSOR CONTROL

The PS-15 is fitted with a dedicated microprocessor system, consisting of a type 8085 CPU, ROM, RAM and I/O ports. The keypad and indicators on the front-panel are connected to the microprocessor with a data- and control-bus. As soon as the microprocessor has finished processing input information, or has completed a control function, it turns itself off, which conserves power when the instrument is used with batteries.

When the Level Generator is switched off, the settings previously entered from the front-panel controls are stored in a CMOS-memory as long as the instrument is not disconnected from the a.c. mains supply, or if it is being supplied by the (optional) BAZ-15 Battery Pack. These stored settings are called up when the set is switched on again, but the send level is blanked.

If there is an interruption in the a.c. mains supply, or the battery voltage is too low, a standard setting will result; the values for this are given in Section 3.5.

2.4 POWER SUPPLY

The PS-15's power supply system can be run from a.c. mains or from batteries (using the optional BAZ-15 battery pack). The built-in charger unit will charge-up the batteries when the instrument is being run on a.c. mains, even when measurements are being made.

The power supply circuit is designed to switch the instrument off when the battery voltage is too low, thus protecting the batteries from deep discharge, and also preventing erroneous readings. The automatic voltage monitoring circuit will also switch the PS-15 off, when used on a.c. mains, if the voltage drops below the rated tolerance level.

When the remote control option is fitted, (on request) the instrument may only be a.c. mains powered.

Important Safety Instructions

A.C. power line voltage

The operating voltage of the instrument should be the same as the a.c. line voltage, so check whether or not the two voltages are equal.

Safety Class

This instrument is categorized as Safety Class I according to VDE 0411 or IEC Publ. 348. The power cord delivered with the equipment has a protective ground conductor. The a.c. power plug must be plugged into an a.c. power receptacle that has a third wire to ground, except in rooms that are particularly certified otherwise. Any disconnection of the protective ground conductor either inside or outside of the instrument is not permitted.

Connection to measuring circuits presenting hazards to personnel

Before the connection is made to a hazardous circuit, a protective ground connection, for protection against the measurement circuit, ought to be connected to the enclosure. In case the protective ground conductor of the a.c. power line can also assume this protective function, the a.c. power connection should be established first of all. If the measuring circuit has an inherent protective ground conductor, then this conductor must be connected to the enclosure before a connection is made to the measuring circuit.

Defects and Exceptional Conditions

When it can be assumed that safe operation is no longer possible, the equipment should be taken out of service and inadvertent operation should be prevented.
This occurs when

- the equipment shows external signs of damage
- the equipment no longer operates
- after being overstressed in any way (e.g. storage, transport) so that the tolerable limits are exceeded.

Fuses

Only specified fuses are permitted for use.

Opening the Instrument

After the covers have been removed or when components are removed with tools, certain components that operate with applied voltage could be exposed. And also connection points might be carrying a voltage.
Therefore, before the instrument is opened for inspection, all voltage sources should be disconnected.
But sometimes calibration, maintenance or repairs require that the instrument be open and operating with applied voltage. So only experienced craftspersons who understand the dangers associated with working on instruments that have exposed voltage points should undertake the job.
Capacitors can retain a voltage charge even after the instrument has been disconnected from voltage sources. Thus, the circuit diagrams should be observed.

Repairs, Replacement of Components

Repairs must be done according to correct technical practice. With that, particular attention must be paid to the characteristics of construction. None of the safety precautions should be changed, especially for leakage paths and air gaps, and separation by insulation must not be reduced.
Only original replacement parts ought to be used. Other replacement parts are only permitted if the safety and protection against human injury are not degraded through the use of non-original components.

Safety Testing after Repair and Maintenance

Testing of the protective ground conductor in the power cord for the instrument:

The resistance of the protective ground conductor shall be measured. It should be $<0.5\,\Omega$. The power cord should be bent and kinked during the measurement so as to reveal any intermittent connection. This gives evidence of a defective power cord.

Testing the insulation of the a.c. power circuit:

The insulation resistance is measured at 500 V between the a.c. power connection and the protective ground conductor connection. For this measurement, the instrument's power switch should be ON.
The insulation resistance ought to be $>2\,M\Omega$.

3 SETTING-UP FOR OPERATION

3.1 UNPACKING THE INSTRUMENT

The instrument is supplied in packing which has been specially developed by Wandel & Goltermann after extensive load-testing of the materials. This guarantees that the instrument will not be damaged even under the most demanding transport conditions. The instrument should be carefully removed from the packing in the manner indicated on the carton. We recommend that the original packing be kept in case the instrument needs to be transported at a later date. If the original packing has not been retained, the following procedure should be adopted:

3.1.1 INSTRUCTIONS FOR TRANSPORT

Transportation without damage is only possible when correctly designed packing is used. If the original packing is not available, the instrument should be packed as shown in Fig. 3-1.

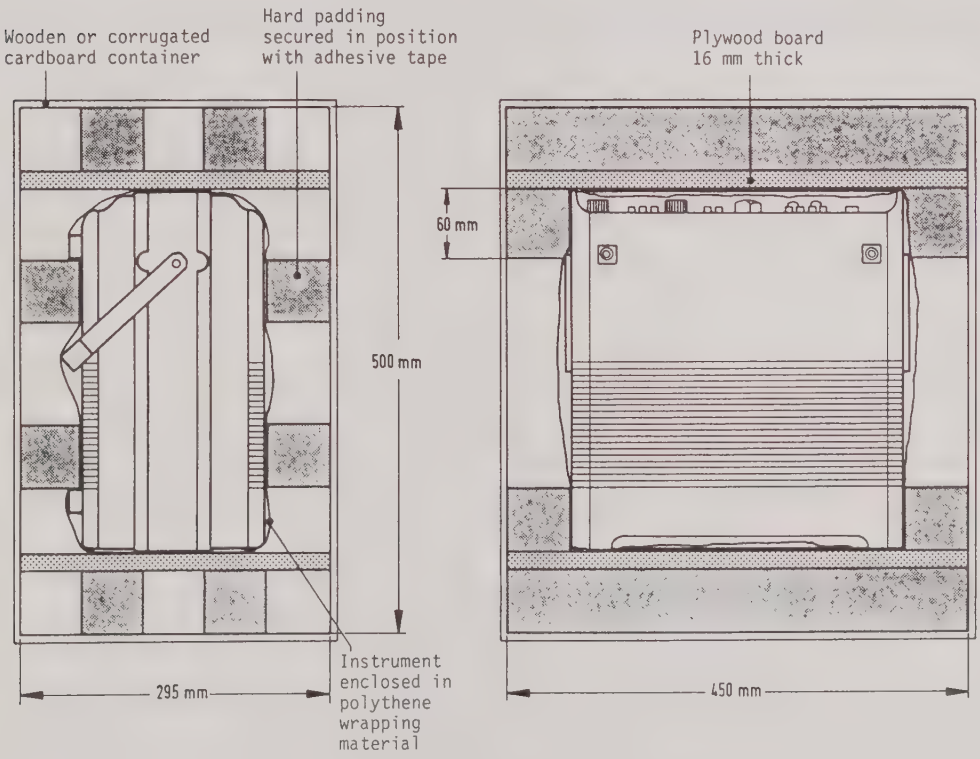

Wooden or corrugated cardboard container
Hard padding secured in position with adhesive tape
Plywood board 16 mm thick
60 mm
500 mm
Instrument enclosed in polythene wrapping material
295 mm
450 mm

Figure 3-1 Packing instructions

3.1.2 PROTECTIVE COVERS

The instrument can be kept dust-free during transport and storage by fitting covers to the front and rear panels. These covers also protect the controls from damage. The covers can still be used when the BAZ-15 battery pack is fitted; fitting the front protective cover switches the instrument off. A set of protective covers is available under reference number SD-940.

3.2 SETTING-UP THE INSTRUMENT

The instrument can be used in ambient temperatures of between 0° and +50°C (see Specifications section).

When the instrument is used within large installations or built into a rack, it is important that these temperature limits are not exceeded (see Section 3.2.1).

The transport and storage temperature range is from -40°C to +60°C. We recommend the use of the protective covers whenever the instrument is stored or moved. (See section 1.8 for order information and Section 3.1.2 for further details).

For ease of operation, the carrying handle can be swung down to act as a tilting prop. Press the knobs situated on the handle pivots, and move the handle down until it locks.

3.2.1 19" RACK MOUNTING

The instrument can be fitted into a 19" rack, and a conversion kit is available for this purpose, order No. BN 4502/00.16. As shown in Figure 3-2, this consists of a front panel with handles, a rear panel, two side panels and a cover. This kit replaces the normal instrument housing, and is fitted as described in Section 5.2.3.

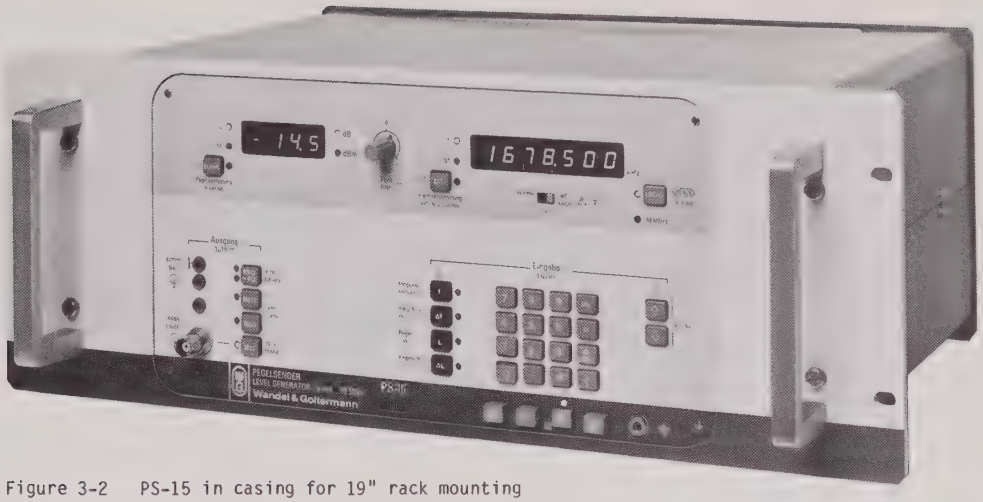


Figure 3-2 PS-15 in casing for 19" rack mounting

N.B. It is important that the upper temperature limit for operation of the instrument is not exceeded when the set is built into a rack system. Generally speaking, the following conditions should be observed:

- A space of 1 U (44 mm) should be left between each instrument
- A fan must be built-in to remove warm air from the cabinet.

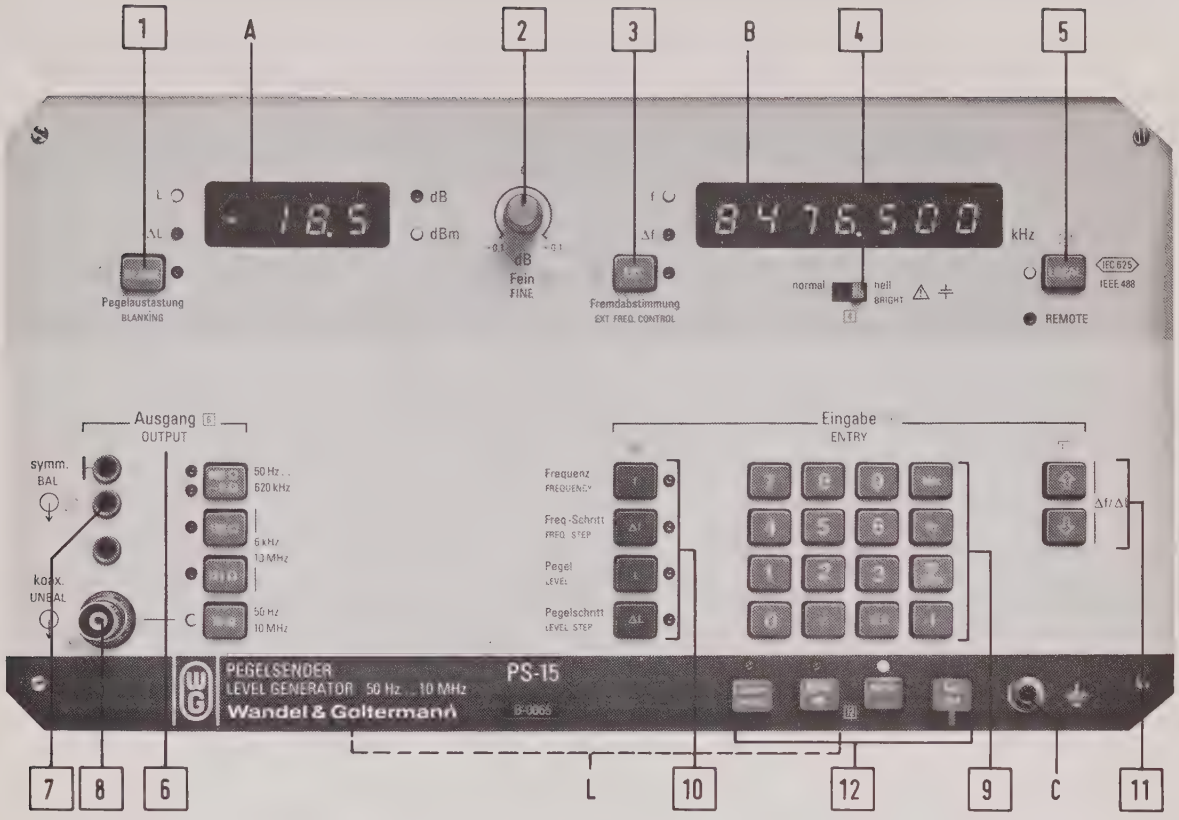


Figure 3-3 Front view, PS-15 (BN 954/01 Version)

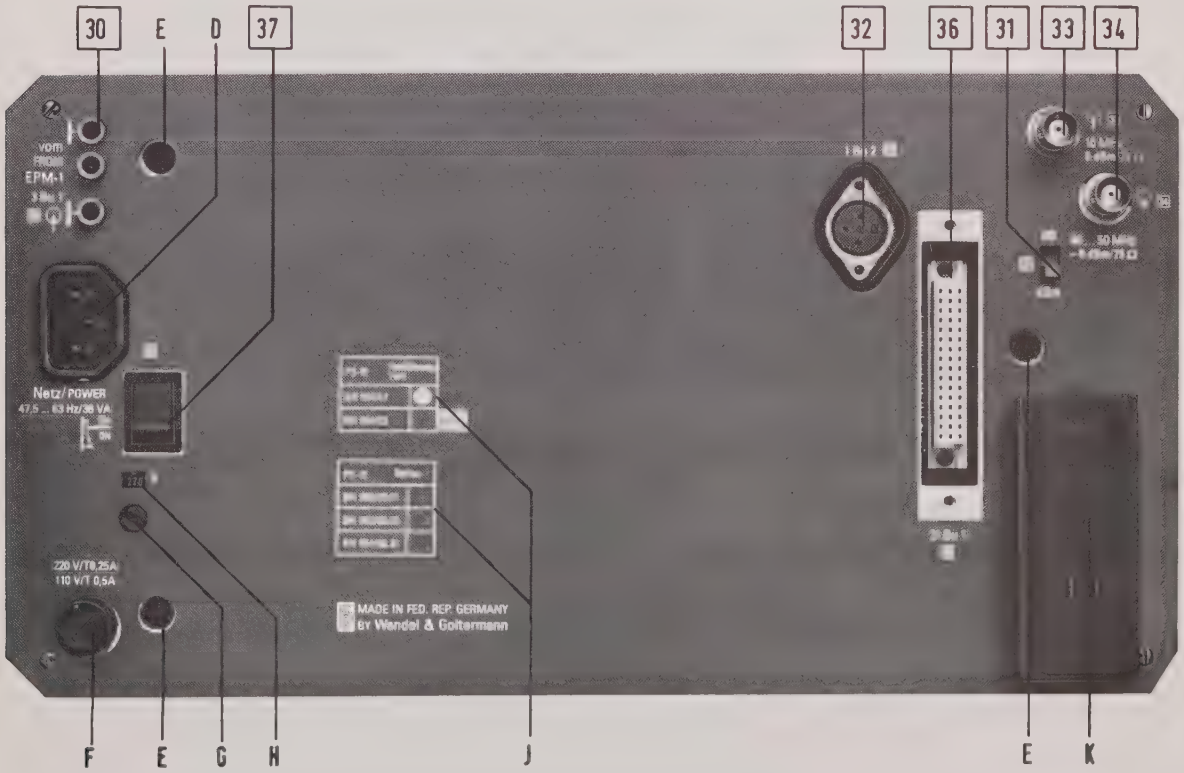


Figure 3-4 Rear view, PS-15

Control Symbol	Abbreviation used in circuit diagrams	Control	Function
[1]	9 S 1	"BLANK"	"Soft"-switching (in and out) of send level
[2]	3 P 2	"fine" level	Fine control (±0.1 dB) of level
[3]	9 S 2	"EXT."	Connects external frequency source (e.g. SPM-15)
[4]	9 S 30		Indicator brightness
[5]	9 S 29	"LOCAL"	Allows manual operation when unit is remote-controlled
[6]	9 S 25 ... 28	Switches and connectors for various outputs:	
[7]	7 Bu 3		Balanced output 50 Hz to 620 kHz or 6 kHz to 10 MHz
[8]	7 Bu 5		Coaxial output 50 Hz to 10 MHz
[9]	9 S 5 ... 20	Numerical keypad for frequency and level setting:	
		"kHz", "Hz"	Keys enter the frequency input
		"dB/dBm"	Key enters the level input
		".", "CLR"	decimal point, clear key
		"+"	sign key for level
[10]	9 S 21 ... 24	Keys for entering and recalling send parameters:	
		"f", "Δf"	frequency, frequency step
		"L", "ΔL"	level, level step
[11]	9 S 3, 9 S 4	"⇧", "⇩"	keys to increase or decrease the level or frequency

Table 3-1 Controls and connections on the front-panel (see Figure 3-3)

Control Symbol	Abbreviation used in circuit diagrams	Control	Function
[12]	1 S 1, I ... IV	Power supply switch (only one switch to be pressed at any given time)	
		"CHRG"	Charges the batteries (option BAZ-15) using a.c. mains
		"SEND ⏚ "	Battery operation when option BAZ-15 is fitted
		"SEND ~ "	A.C. mains operation
		"OFF"	Switches off instrument Instrument is also switched off by fitting the protective cover (SD-940)
A	9 IC 43 ... 46		Send Level Indicator
B	9 IC 47 ... 53		Digital Frequency Indicator
C	1 Bu 1		Earthing socket

Table 3-1 Controls and connectors on the front panel (see figure 3-3) (continued)

Control Symbol	Abbreviation used in circuit diagrams	Function
[30]	3 Bu 1	Input for external level regulation using EPM-1.
[31]	9 S 31	dB/dBm changeover switch
[32]	1 Bu 2	Battery input from BAZ-15 (optional)
[33]	51 Bu 2	Input for 10 MHz frequency standard
[34]	4 Bu 2	Input for control frequency, 40 to 50 MHz e.g. from SPM-15
[36]	-	Female connector for <IEC 625> Interface Bus (optional)
[37]	1 S 3	Mains isolating switch
D	1 St 1	A.C. mains input socket
E		Threaded insert for securing BAZ-15 option or Interface-Bus
F	1 Si 1	Mains fuse
-	1 Si 2	Battery fuse (see 3.4.3)
G	1 S 2	A.C. mains voltage selector switch
H		Indicates mains voltage selected
J		Identification plate (Model and options)
K		Accessory compartment (contains spare fuses, allen key, socket mounting-key and board extractor)
L	-	Drawer containing abridged operating instructions

Table 3-2 Controls and connectors on the rear panel (see Figure 3-4)

3.3 CONTROLS AND INDICATORS

The front panel controls of the PS-15 Level Generator are divided into three functional groups: connectors, operational controls, and indicators. All measurement conditions are set by means of push buttons; each function is indicated by means of a LED which is illuminated when the function is being used.

The lower part of the front panel contains the connectors and operating controls; the coaxial and balanced outputs, together with the selectors for output impedance and output, are on the left-hand side; the keyboard for setting the send level and frequency is on the right-hand side.

The upper part of the front panel consists of the 3 digit level display, the 7 digit frequency display, and switches for additional functions. On the back of the instrument are the control connections and power supply components.

The abbreviations for controls and sockets that are used in the operating manual are shown in the fold-out illustrations, Figures 3-3 and 3-4.

Tables 3-1 and 3-2 give the relationships between the abbreviations and the circuit diagram codes used in the Appendix. The circuit diagram abbreviations have the following meaning: e.g. 7 Bu 3: The balanced output socket is shown on circuit diagram No. 7 and is labelled Bu 3 on that diagram.

Numbers in square brackets [ ], which appear in the text or in tables, refer to the numbers printed in squares on the instrument front and rear panels. Switches are referred to thus: "XYZ"; e.g. "f" means the pre-selection switch for entering the send frequency.

The tables also briefly describe the functions of the various controls and connectors. The coaxial connector on the front panel of version BN 954/01 is a universal connector which is easily converted to mate with the connectors commonly used in telecommunications technology (see Section 5.2.2).

3.3.1 ABRIDGED OPERATING MANUAL

An abridged operating manual is contained in the drawer underneath the instrument. When this drawer is fully extended, the individual pages of the manual are accessible. Each page can be slid back in the drawer so that the page underneath can be read. When the drawer is closed and re-opened, all the pages are once more at the front of the drawer. A thumb-index is provided.

The abridged operating manual contains instructions for setting the frequency and level. When the instrument is used for the first time, or when making complex measurements, we recommend that the full Description and Operating Manual be used.

3.4 POWER SUPPLY

3.4.1 A.C. MAINS OPERATION

The PS-15 derives its power from a regulated power supply. The instrument should be connected to a.c. mains with a frequency of between 47.5 and 63 Hz. Before connecting the instrument to a.c. mains, check that the operating voltage (shown in the viewing window H on the rear panel of the set) corresponds to the nominal a.c. mains voltage.

The following nominal a.c. voltages can be selected using the a.c. mains voltage selector switch G: 110/117/127/220/227/237 V. The following fuse types should be used:

110/117/127 V:	T 0.5 A (0,5 A slow-blow)
220/227/237(235) V:	T 0.25 A (0,25 A slow-blow)

The mains fuse F should be changed, if necessary, to correspond with the above values if a new a.c. mains voltage is selected.

The cable supplied with the set should be used for connecting to a.c. mains. The instrument complies with the specifications in VDE 0411 and IEC Publ. 348 for Safety Class I, i.e. the instrument case and the earthing socket are connected to a protective earth. If any other type of a.c. mains cable is used, it is important that a protective earth is connected. A.C. mains connection is completed by plugging the cable into the socket D on the back of the instrument. Pressing the "SEND ~" switch will switch the instrument on.

If nothing happens, check the fuse F, or the mains isolating switch [37], located on the back panel. This switch is fitted to instruments from Series B onward, due to the increased power consumption when the remote control option is fitted (modified power supply unit).

The specifications given in Section 1 apply immediately after switch-on.

To switch the instrument off, press the switch marked "OFF". Replacing the front protective cover (SD-940, optional) will also switch the set off. If the a.c. mains isolator switch is operated, the supply current input circuit is isolated from the a.c. mains.

3.4.2 BATTERY OPERATION

The PS-15 can be operated independently of an a.c. mains supply by the installation of the BAZ-15 Battery Pack option, which contains 12 rechargeable cells, type IEC KR35/62, each with a capacity of 4 Ah.

The battery pack is attatched to the rear panel of the PS-15 by means of three captive screws, (threaded inserts E in Figure 3-4). The power supply to the PS-15 from the BAZ-15 is via a 3-pole connector [32].

The instrument is switched on by pressing "SEND ⏚" which is found on the front panel. Approx. 5 hours use can be obtained from fully charged batteries. If the battery voltage is too low, a voltage monitoring circuit in the main instrument switches off the power supply and all indicators and LEDs. This prevents erroneous readings, and protects the batteries from deep discharge. Measurements can be made immediately after the instrument is switched on. The batteries may be re-charged by connecting the instrument to the a.c. mains and pressing the "CHRGE" button. The corresponding green LED should light, charging being accomplished using the PS-15's built-in charger. Charging time is approx. 14 hours.

If an instrument, fitted with a BAZ-15, is used on a.c. mains (by pressing "SEND ~"), the Level Generator is powered from the a.c. mains, and the batteries are trickle-charged.

Note: We recommend charging the batteries before using the instrument for the 1st time.

The batteries are protected from short circuits by a 3 A slow-blow fuse (1 Si 2). Instructions for replacement are found in Section 3.4.3.

3.4.3 REPLACING FUSES

The internal power supply is a switched-mode type which has electronic short-circuit protection. The fuse will only blow if there is a massive overload in either the mains or battery circuits.

A.C. mains operation

It is unlikely that the fuse will blow in normal operation. The mains fuse must be changed, however, when changing over from 110 V to 220 V mains, or vice versa.

Proceed as follows:
- remove plug from a.c. mains socket
- unscrew the cap of the fuse-holder F
- remove the fuse and replace with the appropriate value as indicated in Section 3.4.1

Fuse values are also printed on the back panel of the instrument; spare fuses are contained in the accessory compartment K, also on the back panel.

Battery operation

In the unlikely event of the battery protection fuse blowing, the following procedure should be adopted:
- Remove the BAZ-15
- Remove the top half of the instrument casing by undoing the four allen screws (allen key in accessory compartment K on the back panel)
- lift the chassis out of the bottom half of the casing
- remove the rear cover plate by undoing the four screws
- change the fuse, situated on the right, near the DC/DC regulator (IC 1). Reassemble in reverse order.

3.5 SETTING-UP THE INSTRUMENT AFTER SWITCH-ON

After the instrument is switched on (see Sections 3.4.1 or 3.4.2), the keyboard LEDs [10] flash for a few seconds before going out. The settings which were in use when the instrument was last switched off (by pressing the "OFF" switch) will be reinstated when the instrument is next switched on, as long as a charged battery pack is fitted, or, if the instrument remains connected to the a.c. mains. The mains isolating switch [37] must also be left "on". The output level, however, is always blanked out when the instrument is switched-on, regardless of any previous setting of the blanking switch ("BLANK"), and the red LED "BLANK" is illuminated.

If the battery voltage is too low and all the indicators and LEDs remain off (i.e. the instrument is switched off), and if the mains connection has been interrupted, then when the "SEND ~" switch is pressed and the mains isolating switch [37] is set to "ON", the following standard settings are implemented (see also Section 5.2.4):

Level:	-10 dB or -1 dBm (depending on position of switch [31])
Level step:	1 dB
Frequency:	100 kHz
Frequency step:	10 kHz
Output:	75 Ω, output level damped (red LED on), i.e. level is indicated but not transmitted.

3.5.1 CHANGING THE DISPLAY BRIGHTNESS

With switch [4], the brightness of the displays and LEDs can be switched between "bright" and "normal". In normal lighting conditions, or when the instrument is powered by the BAZ-15 battery pack (optional), it is recommended that the switch be left in the "normal" position. The battery life is thus extended, due to the lower current drain of the indicators, (see Section 3.4.2). If the ambient lighting is very bright, the switch should be set to "BRIGHT".

3.6 SETTING THE FREQUENCY

The frequency is set digitally. First, the "f" switch is pressed (in the row of black switches [10] on the input section [9]). The associated LED comes on, to indicate that a frequency may now be entered using the numerical keypad. After the entry of each figure, the "f" LED flashes to indicate that the entry is not yet complete. (The frequency is shown on indicator B). Entry is completed by pressing the "kHz" or "Hz" keys, which turn off the "f" LED.

As a check that the frequency value shown on indicator B is the current selected send frequency, the "f" LED on the left hand side of the digital display lights up.

3.7 CHANGING THE FREQUENCY USING THE DIRECTION KEYS

A frequency interval, Δf, can be stored in memory and used to increase or decrease the send frequency in discrete steps. After pressing the "f" key, one of the direction keys [11] may be used to alter the current frequency setting:

push ⇧ key once:	Send frequency increases by Δf
push ⇩ key once:	Send frequency decreases by Δf

The special frequency interval, Δf, is set by pressing the "Δf" key, which causes the indicator B to display the value of Δf, signified by the illumination of the LED for the left of the display window. Entry of the frequency step is as described in Section 3.6.

If the direction keys are pressed for an extended time ($\geq$ 1 sec.) the single step switching is changed to continuous mode, with a step every 0.5 second (approx.).

This function allows a "sweep" to be made in discrete frequency steps. If a level meter (e.g. SPM-15), is connected to the output of the test item, and set to "wideband" mode, the frequency response of the test item can be checked using the display section of the level meter. Automatic step-switching ends as soon as the direction key is released.

3.8 SETTING THE LEVEL USING THE KEYPAD

The send-level is set digitally using the digital keypad. The level will be indicated in dB or dBm, depending on the setting of slide switch [31] on the rear of the instrument.

To make an entry, the "L" key is pressed, causing the corresponding LED to light up. The level desired is entered via the keypad and entry is concluded by pressing the "dB/dBm" key. The LED for the "L" key then goes out, and the indicated level is output to the pre-selected output [7] or [8]. The output level is automaitcally assigned a negative value on entry, thus protecting the test item from levels > 0 dB/dBm. If levels of > 0 dB/dBm are required, the "+" key should be pressed either before the entry of numerical values, or before the final pressing of the "dB/dBm" key. Changing the frequency or level without disturbing the rest of the circuit can be accomplished by pressing the "BLANK" key before entering the send level; this "soft"-blanks the output signal. Pressing the "BLANK" key again restores the output, also "soft"-switched.

3.9 FINE SETTING OF LEVEL

The send level can be chosen in steps of 0.1 dB using the keypad. Values lying between these steps can be set using the "FINE" control potentiometer [2], which has a range of $\pm$0.1 dB.

3.10 CHANGING THE LEVEL USING THE DIRECTION KEYS

In the same way as the frequency, the level can be increased or decreased by a discrete amount.

To enter the size of this step, the "ΔL" key is pressed; an adjacent LED illuminates. At this point, the level indicator shows any previously entered value of ΔL.

Note: the units for ΔL are given as dB, irrespective of the setting of the dB/dBm switch [31].

A new value for the level step is entered as described in section 3.8.

The Send Level is increased or decreased by one step (ΔL) if the direction keys are pressed momentarily.

If no special value is set for ΔL, a default value of 1 dB will be set up (see standard settings, Section 3.5).

If a direction key is held down, an automatic level switching sequence is initiated, whereby the level changes by ΔL every 0.5 seconds (approx.) until the key is released or the limits of the range are reached.

3.11 CANCELLING AN ENTRY

If an incorrect value is entered from the keyboard but the entry has not been completed, pressing the "CLR" key will cancel the value without changing the current values of the send parameters. The displayed value is also cancelled by pressing the "CLR" key. The instrument remains in the entry mode, indicated by flashing LED for the chosen parameter (switches [10]).

3.12 OUT-OF-RANGE ENTRIES

The instrument is pre-programmed to reject instructions to exceed the designed ranges of frequency and output level. If a frequency or level which lies outside the range is entered, the instrument automatically sets up the maximum or minimum value. The level limits are dependent on the output conditions (balanced/coaxial, impedance) and are given in Table 3-3 (see also Section 1.2.4).

Output	dBm		dB	
	min.	max.	min.	max.
coaxial, Z_o = 75 Ω	-60.9	+19.0	-69.9	+10.0
balanced, $Z_{out} = Z_L$ = 124 Ω	-63.1	+16.8	-69.9	+10.0
$Z_{out} = Z_L$ = 150 Ω	-63.9	+16.0	-69.9	+10.0
$Z_{out} = Z_L$ = 600 Ω	-69.9	+10.0	-69.9	+10.0
Z_{out} = 0, Z_L = 600 Ω	-63.9	+16.0	-63.9	+16.0

Table 3-3 Pre-programmed level limits

The pre-programmed frequency limits are 0 Hz and 9999.999 kHz.

These stored limits also apply when send data is input via the direction keys. For example, if ΔL is set to 10 dB and "⇧" is pressed when the output level at the coaxial output [8] is already +5 dB, the max. value of +10 dB will appear on the display. If "⇩" is pressed subsequently, the send level will return to +5 dB.

3.13 LEVEL BLANKING SWITCH "BLANK"

The send level is switched in and out "softly" (i.e. without abrupt transitions) by repeated pressing of the "BLANK" key. A red LED indicates when the level is switched out. The output impedance remains constant during switching. Unwanted signals, which may be produced when the send parameters are altered, are not transmitted when the output level is blanked.

3.14 CHOICE OF OUTPUT IMPEDANCE, Z_{OUT}

The coaxial output is selected by pressing the "75 Ω" key; this connects the signal to the Versacon®9 socket [8]. The frequency range of this output extends from 50 Hz to 10 MHz.

The balanced output [7] can be switched to different impedances and frequency ranges. Pressing one of the keys in the output section [6] will select one of the following, depending on the version:

Version BN 954/01

Z_{out} = 124 Ω, 150 Ω frequency range 6 kHz to 10 MHz
Z_{out} = 600 Ω, approx. 0 Ω frequency range 50 Hz to 620 kHz

Version BN 954/02

Z_{out} = 124 Ω frequency range 6 kHz to 10 MHz
Z_{out} = 600 Ω, 135 Ω, approx. 0 Ω frequency range 50 Hz to 620 kHz

3.15 EXTERNAL TUNING

Together with the SPM-15, SPM-18 or SPM-19 (to 10 MHz) Selective Level Meters, the PS-15 Level Generator forms a complete level measurement set-up in which the tuning is then derived from the Level Meter. The send- and receive frequencies are synchronised. To accomplish this, the instruments must be connected together via the coaxial connectors [33] and [34] situated on the back panel (see Figure 4-1).

The frequency display is blanked down to the decimal point. The frequency accuracy is determined by the receiver.

To restore the Level Generator to internal frequency setting, the "EXT" key should be pressed again.

3.16 STANDARD FREQUENCY INPUT

If the frequency accuracy of the PS-15 is not high enough for certain applications, an external standard frequency of 10 MHz can be input via connector [33] on the rear panel of the instrument, to reduce send frequency errors. The level of this signal, if sinusoidal, can be between -10 dB and +10 dB; rectangular signals should have V_{pp} between 200 mV and 2 V (input impedance 75 Ω).

3.17 EXTERNAL LEVEL CONTROL USING AN EPM-1

An EPM-1 Milliwatt Power Meter, BN 564/00 (option) can be connected to input [30] on the back panel to provide an external control voltage, thus forming a control loop. The send level is measured as close as possible to the test item with the test probe of the EPM-1. The control voltage output of the EPM-1, a d.c. voltage proportional to the deviation of the measured signal from the set value, is fed into the input [30] of the PS-15. Using this method, cable losses in long cables, or errors due to the frequency response of the generator or the test cable, can be compensated for.

The PS-15, when used in this way, can also serve as an a.c. voltage level standard of high accuracy, with a send level of 0 dBm or 0 dB over the frequency range 50 Hz to 10 MHz.

Section 4-4 describes the PS-15 output level settings and the test set-up.

4 MEASUREMENT NOTES

The PS-15 Level Generator is an easy to use, compact instrument; a special feature is synthesiser tuning which ensures that the output frequency is extremely stable. Details of frequency and level ranges are found under "Specifications".

The wide range of technical applications is enhanced by the simplicity of operation, particularly when the instrument is used in conjunction with the SPM-15 Selective Level Meter to form a compact measuring set-up.

4.1 MEASUREMENTS UNDER EXTERNAL CONTROL USING THE SPM-15

A compact measuring set-up for determining selective loss and gain is formed by connecting the PS-15 Level Generator to a SPM-15 Selective Level Meter. The generator can be synchronously tuned to the receiver by means of the remote tuning facility; only one instrument has to be set-up as a result. Errors, due to frequency mismatching when the instruments are tuned individually, are thus eliminated. The instruments should be situated close together, so that the two additional connections, (shown in Figure 4-1), can be made easily.

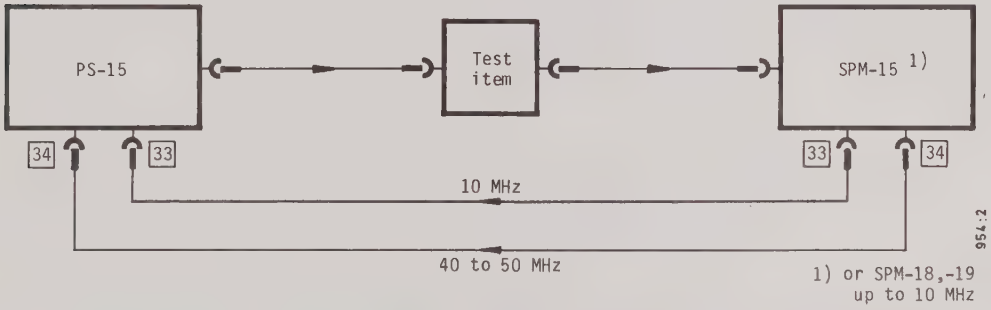


Figure 4-1 Synchronous tuning of PS-15 using SPM-15

4.2 MEASUREMENTS WITHOUT EXTERNAL CONTROL USING THE SPM-15

Some measurements require a frequency difference between the generator and receiver, such as:

(a) Translator measurements
(b) Distortion measurements
(c) Measurements of non-harmonic spurious signals

Other types of measurements require that the generator and receiver are separated by a long distance, for example, when measurements are being made on FDM transmission paths. These measurements can also be made quickly and easily using the PS-15/SPM-15 (or SPM-18, SPM-19, up to 10 MHz) combination. The instruments are connected as shown in Figure 4-1, with the exception of the control connections (connectors [33] and [34]). The two instruments must be tuned separately to the desired frequencies.

4.3 MEASURING HIGH ATTENUATIONS

If measurements on two-port networks with high attenuation values are to be made, a large value return impedance Z_S is necessary between the generator and receiver (see Figure 4-2). If this return impedance is not infinite, voltage drops due to the ground lead resistances, r_1 and r_2, of the test cables, will result in additional errors. For practical applications, these errors can be kept small by making Z_S large in comparison to r_1 and r_2.

The effect of the above mentioned resistances and impedances on the measured attenuation is described in the following section:

The test item is a two-port network with infinite attenuation; Z_S is the return impedance, r_1, r_2 the unavoidable ground lead impedances, which might not be purely resistive[1]. Due to the voltage drop across r_1, caused by the generator current, there is a voltage difference between the chassis of the generator and that of the receiver.

If Z_S is finite, a signal current flows through r_2, causing a signal voltage to appear at the receiver input, thus simulating that the test item has a finite attenuation.

Assuming that r_1 and r_2 are small compared with Z_{out}, Z_{in}, Z_o and Z_S, a simple calculation gives:

$$\frac{U_2}{U_o} = \frac{r_1}{Z_{out} + Z_o} \times \frac{r_2}{Z_S} \times \frac{Z_{in}}{Z_{in} + Z_o}$$

If $Z_{out} = Z_{in} = Z_o$, the effective attenuation,

$$a = 20 \log \frac{U_o}{2 \times U_2} \quad dB$$

$$= 20 \log \frac{2 \times Z_o \times Z_S}{r_1 \times r_2} \quad dB$$

Assuming the worst possible phase angle between the measuring voltage and the error voltage, the above attenuation must be approx. 40 dB greater than the attenuation to be measured, if the measurement error is to be 0.1 dB.

The value of the return impedance, Z_S, is approx. 2 Ω at 100 kHz and increases with increasing frequency (approx. 20 Ω at f > 3 MHz).

If r_1 and r_2 are taken as 10 mΩ each, this being the value of the coupling impedances in a good quality double screened coaxial cable, length 50 cm, and if Z_o = 75 Ω and Z_S has an average value of 10 Ω, then the set-up shown in Figure 4-2 will have an effective attenuation of 143 dB.

---

1) In the relevant literature, r_1 and r_2 for coaxial cables, connectors, etc. are called "coupling impedances", and are defined as follows:

coupling impedance, r_1, = voltage drop on outside of outer conductor / voltage on inside of outer conductor

coupling impedance, r_2, = voltage drop on inside of outer conductor / current on outside of outer conductor

The value calculated on the above assumptions, will lead to a maximum additional error of 0.1 dB if an attenuation of, say, 100 dB is measured with the PS-15/SPM-15 combination.

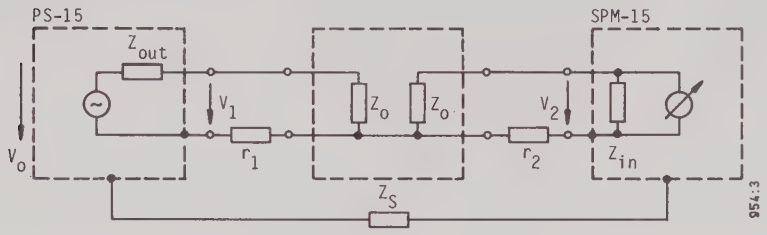


Figure 4-2 Return and coupling impedances between generator and receiver

If poorer quality cable is used (single screened cable may have coupling impedances between 50 mΩ and 200 mΩ per metre), or if long cables have to be used, the return impedance between generator and receiver can be increased by moving the instruments further apart.

Other methods for improving instrument coupling are the insertion of a coaxial choke, type MSD-1, BN 690/00.01, in the external control cable, or else not to use external frequency control.

4.4 0 dBm OR 0 dB LEVEL STANDARD

The output level of the PS-15 can be kept virtually constant over its entire frequency range with the aid of the EPM-1 Milliwatt Power Meter, BN 564/00. Here, the EPM-1 acts as an AGC amplifier, forming a closed control loop with the generator.

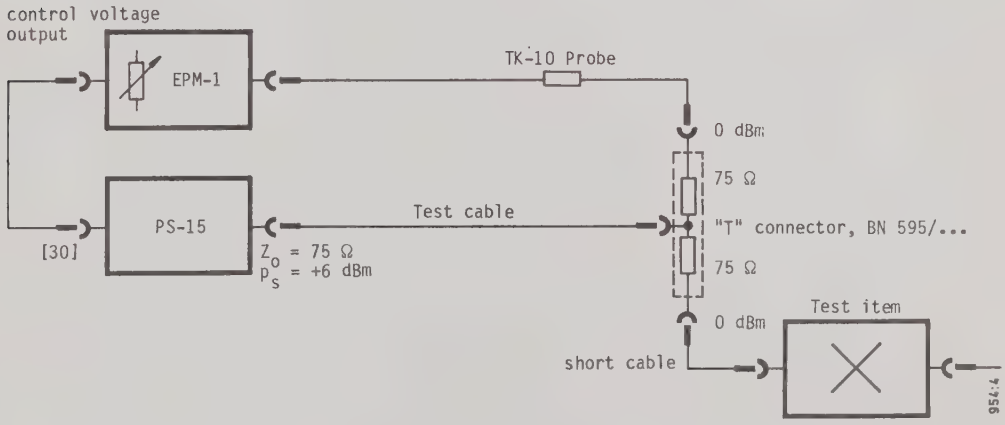


Figure 4-3 Test set-up for external level control (Z_o = 75 Ω)

In the example given in Figure 4-3, the output signal is taken from the coaxial output of the generator, via a "T" connector to the test item. The output level of approx. +6 dB is divided equally (0 dBm) between the test item and the TK-10 test probe of the Milliwatt Power Meter. A d.c. voltage, proportional to the difference between the nominal and the actual value, is taken from the control voltage output of the EPM-1 and fed into the input [30] on the back panel of the PS-15. This method gives a very accurate, non frequency dependent input to the test item, and compensates for errors due to the cables and return losses at the connectors. Residual errors are due only to the frequency response of the test probe, EPM-1 control errors, and any imbalance in the "T" connector. An attenuator, value 9.03 dB, (BN 594/01) is fitted between the "T" connector and the test probe if a level of 0 dB is required with the send level set to +6 dB. Accessories are available for use with the balanced outputs, Z_o = 150 Ω (0 to 2 MHz) and Z_o = 600 Ω (0 to 620 kHz).

5 CHECKING THE INSTRUMENT, MAINTENANCE, ETC.

5.1 CHECKING THE INSTRUMENT

The following tests will check the correct functioning of the instrument, and indicate any major defects (e.g. transport damage).

The tests can be carried out under mains or battery operation; if battery operation is chosen, make sure that the batteries are sufficiently charged (see Section 3.4.2, "Battery Operation").

5.1.1 CHECKING THE LEVEL DISPLAY

Set a level of 0 dB at 10 kHz on the PS-15, and connect the coaxial output to the corresponding input of the SPM-15, using a short cable. Set the Level Meter to "selective" mode, digital read-out, and tune to 10 kHz; it will now indicate the output level of the PS-15. This is stored as a reference value and shown as Level difference (ABS-REF). Set up a 10 dB level step on the PS-15. The measured level should drop by 10 dB each time the "⇩" is pressed, down to a minimum level (for this configuration) of -69.9 dB. When the "⇧" key is pressed repeatedly, the level should increase up to a maximum of +10 dB when the send level reaches the upper range limit.

5.1.2 FREQUENCY CHECK

Leave the output frequency set to 10 kHz and the output level at 0 dB, and connect the output to a frequency meter. After entering a frequency step, sweep through the entire frequency range of the instrument using the direction keys; the frequency shown on the instrument display should be compared with that shown on the frequency meter. Any difference between the two should not be greater than the sum of the PS-15 error limit and the error of the frequency meter.

5.1.3 OUTPUT IMPEDANCE CHECKS

Connect the coaxial output of the PS-15 to the SPM-15, and set the output level to 0 dB. If switch [31] is set to "dBm", the indicated received level should remain constant (within -0.03 dB), whilst the level indicated on the PS-15 should change by +9 dB, corresponding to the difference between voltage- (dB) and power-levels (dBm) in a 75 Ω line.

Now connect the generator and receiver together via the balanced connectors, and tune both instruments to 10 kHz.

Set the impedance selector to 600 Ω and set both instruments for dBm calibration; output level should be set to 0 dBm and "20 dB". No change in output level should be observed when the calibration switch is set to dB, as voltage- and power-levels are identical in 600 Ω networks.

If the input impedance of the SPM-15 is switched to " ∞ " from "600 Ω", the indicated level should rise by approx. 6 dB. If the output impedance of the PS-15 is now switched to low-impedance " ≈0 Ω", the level indicated on the SPM-15 should fall by approx. 6 dB.

If 150 Ω impedance and dB calibration is selected on both generator and receiver, and the input impedance of the SPM-15 is then changed to " ∞ ", the level indicated should rise by 6 dB. Changing the output impedance of the PS-15 to "≈0 Ω" should cause the level to fall again by 6 dB.

If both instruments are set to "dBm", the level indicated on both PS-15 and SPM-15 should rise by 6 dB.

5.2 MAINTENANCE, ETC.

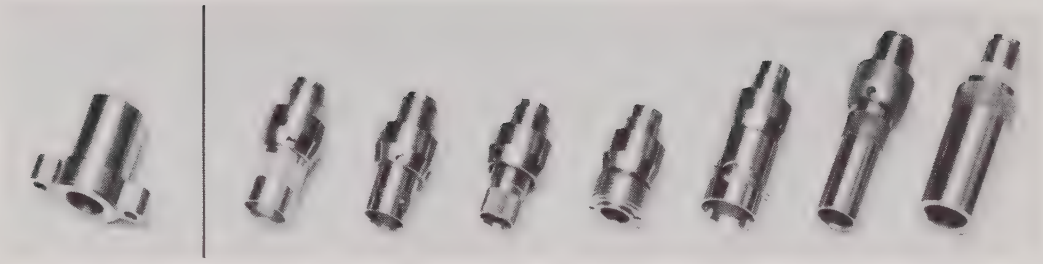
5.2.1 CONSTRUCTION

The PS-15 is built into a compact diecast aluminium casing. By removing the four allen screws on the top of the instrument (using the key which is found in the accessory compartment on the back panel), and lifting off the top cover, the instrument chassis can be removed from the casing. The synthesiser is situated underneath the chassis, and can be swung out of the chassis by loosening the two captive screws found on the back of the unit. To reach the individual boards, contained in screening cans, the covers (located by clips) should be removed by pulling the tab upwards, or, in the case of the output amplifier, by unscrewing the cover.

5.2.2 VERSACON®9 UNIVERSAL CONNECTOR SYSTEM

The coaxial input [8] is fitted with the Wandel & Goltermann Versacon®9 universal female connector, which enables rapid conversion, without soldering, to any of the connector types illustrated overleaf.

The desired connector adapter is simply screwed into the fixed universal socket with the aid of the mounting key, W 1, (found in the accessory compartment on the back of the instrument), and secured with a lock nut. Figure 5-1 shows the connector adaptors which can be used.



Versacon® 9 | Lemo | BNC | 1.6/5.6 | 2.5/6 | 1.6/10 | 558A | 470C Western Electric

Figure 5-1 Versacon® 9 basic female connector with some of the Versacon® 9 adaptors which are available

5.2.3 19" CASE MOUNTING

The instrument chassis may be built in to a case with a 19" wide front panel, BN 4502/00.16 (option) as follows:

- remove the instrument chassis as described in 5.2.1

Dismantling the 19" casing:

- remove the rear panel by undoing the 4 screws
- remove the top dust cover by undoing 2 screws on each side

Fitting the instrument chassis:

- Stand the casing sideways on one of the handles
- fit the instrument into the front of the casing
- put on the rear panel and attach loosely with the 4 screws
- place the instrument in the normal operating position, and replace the dust cover
- tighten all screws

5.2.4 RESET

After fitting a BAZ-15 or after repairs, the last instrument settings stored in the RAM may be lost, without the microprocessor recognising this fact. In this case, the instrument has an undefined setting, which may also mean that the keyboard is inoperative. An extra safety reset has therefore been provided. Proceed as follows:

- remove the top cover (see Section 5.2.1)
- press the reset button at the back of the CPU board

On reset, a defined instrument setting will result, which corresponds to the standard settings given in Section 3.5.

The positions of the DIP switches are for testing and servicing purposes only, and should not be altered!

6 REMOTE CONTROL USING THE <IEC 625> INTERFACE BUS

6.1 INTRODUCTION

The PS-15 Level Generator is a microprocessor-controlled instrument, all the functions of which can be controlled from a desk-top computer or process controller.[1)] In order to do this the instrument can be fitted with a remote-control board conforming to the DIN IEC 625 norm (byte-serial bit-parallel interface system). This differs from the commonly used IEEE 488/78 or HP-IB systems only in the type of connector used; as regards the electrical properties, it is identical. With this system, up to 15 instruments (incl. computer) can be linked together to form a flexible, powerful test system very easily.

All the instruments in the system are connected in tandem on the IEC bus system; each instrument thus has access to all of the bus lines. Depending on the type of instrument, an instrument can act as TALKER (put data onto the bus) or as LISTENER (receive data from the bus). It is, of course, necessary that only one instrument at any one time is acting as TALKER, and that only one instrument acts as controller. Such factors as operating speed, memory capacity, controller programming and the IEC bus functions required will determine the choice of controller which will produce a workable system. All data on the bus is in ISO 7 bit (ASCII) code.

This manual contains some examples of programs for setting and reading the Level Generator using a controller. These will be of help to those having little programming experience, as they explain the method of programming our instruments and several special features of the PS-15.

A knowledge of the manual operating procedures for the instrument and the general characteristics of the IEC bus system (see e.g. IEC 625 Interface Bus brochure, order no. 6930/00.39) is useful.

Wandel & Goltermann also supply complete turnkey systems, which eliminate the need for the user to be involved with the mechanical and electrical properties of the instruments or with the techniques used in programming the various functions.

---

1) For rapid level measurements and the processing of large quantities of data, we recommend the use of the PS-19 Level Generator (80 Hz to 25 MHz).

6.2 INSTRUMENT SET-UP

An automatic test system using the IEC 625 interface system is shown in figure 6-1. Adaptors and connectors are available for systems using the IEEE 488 or HP-IB interface (see figure 6-4).

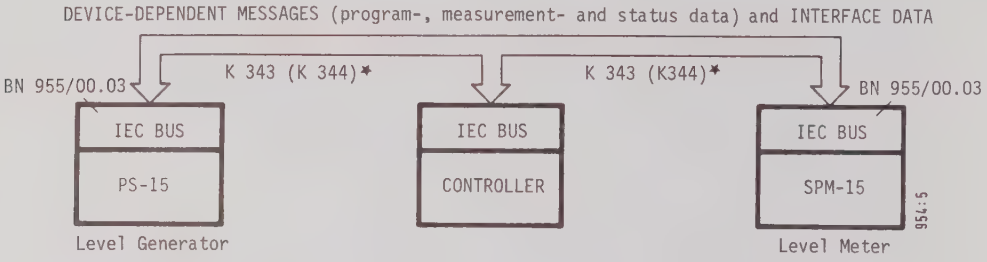


Figure 6-1 Computer controlled level measuring set-up using IEC 625 interface

In the example given, a complete level measuring setup comprising the PS-15 Level Generator and the SPM-15 Level Meter, is controlled in this way.

The system is set up by fitting the interface boards into the various instruments and the controller, and setting the addresses before connecting the instruments together. All the requirements and settings are dealt with in the following sections.

6.2.1 <IEC 625> REMOTE-CONTROL BUS INTERFACE BOARD, BN 955/00.03

The IEC bus board BN 955/00.03 must be fitted before the instrument can be operated in an automatic system. The board is supplied as an option, fitted into a case (overall size: 250 mm x 145 mm x 70 mm approx.). The unit is fitted to the PS-15 by removing the small blanking plate over socket [36] and fixing the unit in place with the three captive screws (see figure 3-4, threaded bushes E). The connection between the internal and external interfaces is made using the 32-way connectors. It is not possible to operate the instrument from the BAZ-15 Battery Pack when the IEC board is fitted.

For protecting the casing during transportation, the SD-940 Protective Covers should be used (available as option).

If the instrument will not respond to remote control commands, even though the instrument address has been set correctly, (see below), remove the cover of the IEC bus board casing and check that the following solder links are in place (see figure 6-2):

A 128/B 112/C 4/G/IH/RST 7.5

---

*) If HP 9816 is used as controller, min. cable length = 3 metres.

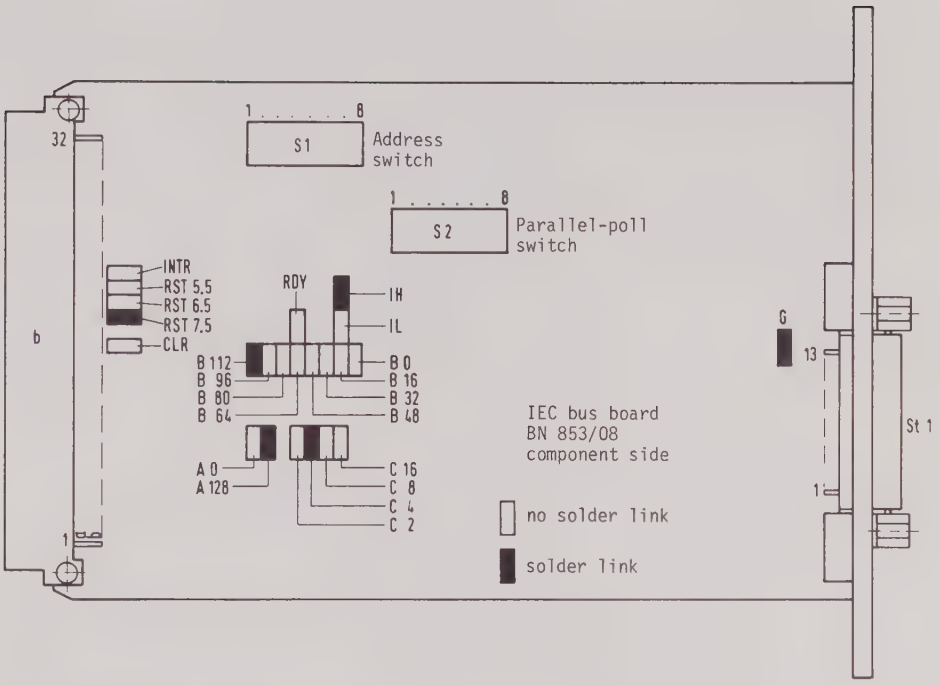


Figure 6-2 IEC bus board BN 955/00.03 for PS-15

Note: If the IEC bus command IFC (interface clear) is to be used to clear both the interface and the instrument, the CLR wire link must be fitted. If this is the case, the IFC command will cause a DEVICE CLEAR and a GO TO LOCAL command to be issued.

6.2.2 INSTRUMENT ADDRESS AND PARALLEL POLL FUNCTION

Each instrument in the system must have a unique address so that the controller can talk/listen to each individual instrument. The address for the PS-15 is set with S 1 on the interface board in binary code.

Example: setting up address 3 (decimal) = 00011 (binary)

Address

Address switch S1
(see figure 6-2)

Position	5	4	3	2	1	
Setting	0	0	0	1	1	
Value	16	8	4	2	1	≙ 2 + 1 = 3

Switch positions 6, 7 and 8 are not used in the PS-15.
It is very important to ensure that no two instruments in the same system have the same address or the address of the controller (HP controllers are address 21). A maximum of 31 addresses are available (0 to 30).

If the interface board is fitted, the address which has been set will be displayed by the PS-15 after switch-on and successful completion of the self-test routine (e.g. if address no. 3 is selected, the display will show A-03). Any change made to the address setting only becomes valid when the instrument is switched off and then on again.

The PARALLEL POLL function which is implemented on the IEC bus board enables the instrument to put a status bit on to one of the lines DIO 1 ... DIO 8 in response to a parallel poll from the controller, without first needing to be addressed as talker.

This allows the simultaneous identification of up to eight instruments connected to the bus which have sent a SRQ (SERVICE REQUEST) to the controller.

The data line which will be used by the instrument in the event of a parallel poll is set with the instrument switched off using S 2 (see figure 6-2). As delivered, all the positions of S 2 are set to OFF.

Example: Parallel poll response is to be on DIO 5

Parallel poll switch S 2

Only position 5 is switched on.
The status of the data lines is interpreted as a binary pattern and read in as 2^{5-1} as a control variable.

Once the address and (if required) the parallel poll function have been set, the instrument can be connected into the bus system as described in 6.2.3.

6.2.3 CONNECTION TO THE BUS SYSTEM

The IEC bus board is fitted with a 25 way Cannon D type connector; the pin connections are as shown in figure 6-3 (left). IEC bus cables of various lengths are available for connecting up the system (see figure 6-4). Maximum cable length between instruments is 4 metres.[1] Care should be taken to ensure that no cables are left open-ended, and that all instruments are switched on after they have been connected to the bus system.

Up to 15 instruments can be connected to the same bus; the maximum length of the complete bus must not exceed 20 metres (see DIN IEC 625, Part 1 section 31.1, p. 66 and section 39, p. 71).

The length of the bus can be increased if 2- or 4-wire interface couplers or modems are used.

The interface board is supplied complete with adaptor S 834, a 24 way Amphenol connector, which enables the instrument to be connected directly to IEEE 488 or HB-IB systems controllers. The pin connections are shown in figure 6-3 (right).

---

1) IF HP 9816 is used as controller, min. cable length = 3 m.

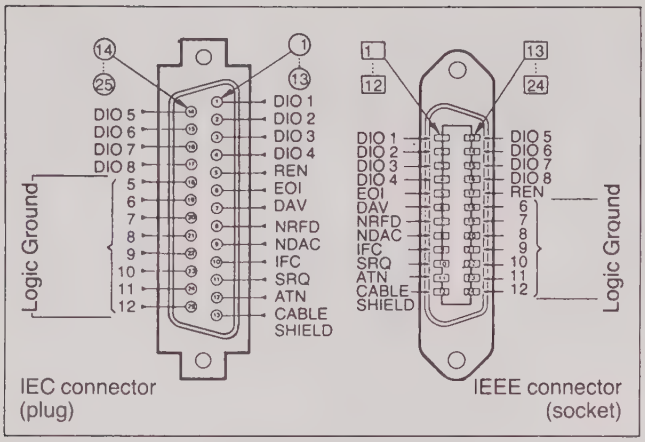


Figure 6-3 Bus connectors: pin connections

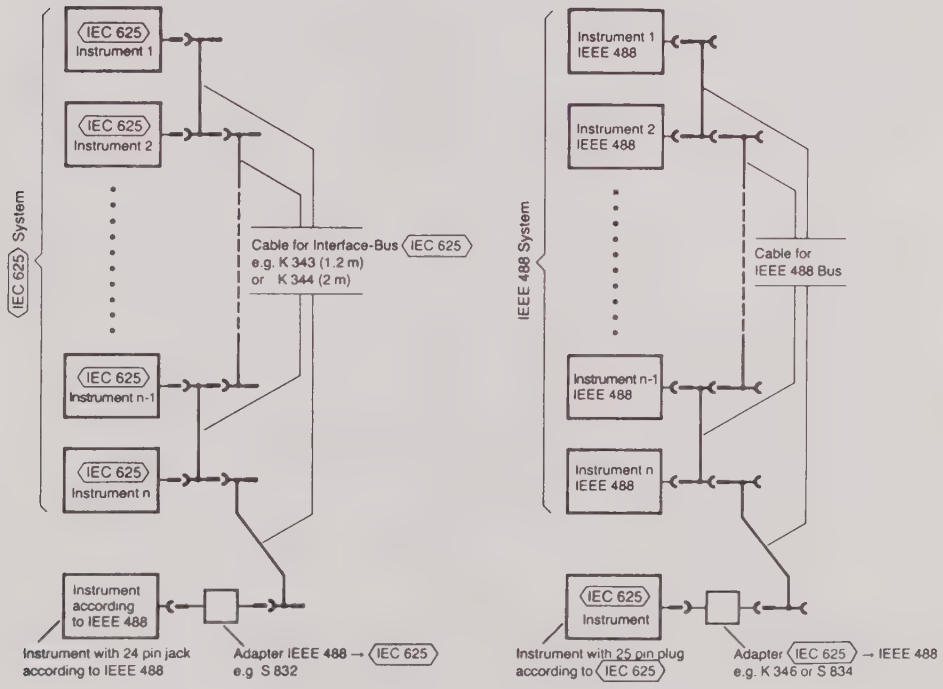


Figure 6-4 Connecting IEC 625 and IEEE 488 systems together

6.2.4 INTERFACE FUNCTIONS

Table 6-1 shows the interface functions (corresponding to the DIN IEC 625 norm) which have been implemented for the PS-15. A more detailed description of the interface functions and the abbreviations used is given in the IEC 625 Interface Bus brochure (order no. 6390/00.39).

Function		Comments
SH 1	Source Handshake	Full implementation
AH 1	Acceptor Handshake	Full implementation
T 6	Talker	All functions except TON (Talk only) and secondary addressing
L 4	Listener	All functions except LON (Listen only) and secondary addressing
SR 1	Service Request	Full implementation
RL 1	Remote/Local	Full implementation. Manual operation blocked by LLO command.
PP 2	Parallel Poll	Function activated with switch
DC 1	Device Clear	Full implementation
DT 1	Device Trigger	Full implementation
C Ø	Controller	Not applicable
E 1	-	Open collector driver

Table 6-1 List of interface functions implemented

6.3 PROGRAMMING

The following programming examples assume that a HP-85 controller fitted with the IEC bus interface 82937 A and I/O ROM is used for programming the PS-15. Section 6.3.2 lists the IEC bus BASIC statements of the HP-85 and similar controllers together with the corresponding IEC bus commands which are used to program the PS-15.

6.3.1 FAMILIARISATION WITH PS-15 PROGRAMMING

Problem:

Generator level and frequency are to be set and the measurement data (here setting data) called up and printed out.

Preparation:

First plug the adaptor S 834 (supplied) into the IEC socket of the remote control board fitted to the back of the PS-15. Next, plug the IEEE 488 cable from the HP-85 into the adaptor. For controlling the generator level, the 75 Ω coaxial output of the PS-15 is connected to the input of a wideband level meter (e.g. SPM-15 set to wideband mode and 0 dBm range).

Method:

If the controller in the system has the interface select code 7, and the PS-15 has IEC bus address Ø2, the BASIC commands listed in table 6-2 can be entered using the keyboard, and executed by pressing the END LINE key. The commands can also be entered in the manner of a normal program, each line preceeded by a line number. This program can then be executed stepwise with the controller in TRACE mode.

Notes: 1. The programming data which consists of single program words (e.g. "P2,") used for setting the PS-15 is described in more detail in section 6.4.

2. Each program word (PW) is terminated with a comma; this is particularly important at the end of several PWs which are written together (e.g. "T1,L-Ø1Ø.5,").

3. Depending on the position of switch [31] on the back of the PS-15, either voltage (dB) or power (dBm) levels will be displayed and called up by the controller (the dBm setting has been chosen for this example).

No.	Operations, IEC bus commands	BASIC commands to be entered from HP-85 keyboard	Display on PS-15 or wideband level meter; notes
1	Interface Clear (IFC) and Remote Enable (REN); and:	ABORTIO 7	- ; sets up defined output state
2	Basic setting of PS-15 (DCL), if the CLR link is in place on the IEC bus board		As for 3 and 4, but REMOTE LED off as PS-15 is not addressed as LISTENER
3	Remote Enable (REN)	REMOTE 7	- ; not needed if 1 has been executed
4	Basic setting (SDC) (see 6.4.2)	CLEAR 7Ø2	red REMOTE LED on; address A-02 displayed; green LEDS flash (wait loop); generator off ("BLANK" LED on); display -1 dBm, 100 kHz, 75 Ω; not needed if 2 has been executed.
5	Program data: generator on	OUTPUT 7Ø2; "GØØ,"	red "BLANK" LED off, connected wideband level meter shows -1 dBm
6	Set generator level to -8.5 dBm, f = 250.400 kHz	OUTPUT 7Ø2; "L-ØØ8.5, FØØ25Ø4ØØ,"	Display reads -8.5 dBm, 250.400 kHz
7	Set PS-15 for triggered measurements	OUTPUT 7Ø2; "T1,"	PS-15 waits for trigger from IEC bus; any further settings are only effective after the trigger (no. 9)
8	Set generator level of +1.5 dBm	OUTPUT 7Ø2; "L+ØØ1.5,"	Display remains unchanged; setting only executed after TRIGGER 7Ø2 (no. 9)
9	Trigger setting	TRIGGER 7Ø2	The new, higher level is set and displayed
10	Call up measurement data (here generator level) from PS-15 and enter in string variable P$ (or numerical variable P)	ENTER 7Ø2 USING "%,%K"; P$ ENTER 7Ø2 USING "%,%K"; P	As "D1," (see PW "D") set the basic setting, only generator level is called up
11	Printout of data as string (or numerical value)	PRINT P$ (PRINT L)	G +ØØ1.5 1.5
12	Switch to manual operation = Go To LOCAL (GTL)	LOCAL 7Ø2	red REMOTE LED off, IEC bus line REN is still true, however.
13	Set generator level and switch back to remote operation	OUTPUT 7Ø2; "L-2Ø.Ø,"	red REMOTE LED on again; REMOTE 7(Ø2) not needed! Trigger mode T1 (no. 9) reactivated, i.e. setting only executed after TRIGGER 7Ø2 (no. 14)
14	Same as no. 9; possible next step no. 10	TRIGGER 7Ø2	Level display reads -20.0 dBm

Table 6-2 Initial programming of the PS-15

6.3.2 PRINCIPLES OF PROGRAMMING

The example given in 6.3.1 is intended to give those users unfamiliar with the programming of our instruments an insight into the way the instrument reacts to the various BASIC statements given from the controller (HP-85). Depending on the use, the controller will automatically address the instrument as LISTENER (receiving data from the controller) or TALKER (transmitting data such as generator level, generator frequency, error messages, etc. to the controller).

6.3.2.1 Preparation

Before program data can be transmitted to the instrument, it must first be switched from manual to remote operation. Remote enable (REN) is accomplished with the HP-85 statements

```
ABORTIO 7
or REMOTE 7
```

where 7 is the controller interface select code.

The command ABORTIO 7 additionally clears the interface (IFC), setting up a defined set of output conditions on the bus. If the CLR link is fitted on the interface board (see 6.2.1) the level generator is reset to its basic settings at the same time (see 6.4.2).

If the CLR link is not present, the IEC bus command SDC resets the addressed instrument to its specific output settings. This also ensures that no function is set that may lead to erroneous operation of the test sequence. The HP-85 controller initiates this command with the statement

```
CLEAR 702
```

By calling up the address of the instrument (02), it is addressed as LISTENER, and all keys on the front panel, with the exeception of the LOCAL key, are then disabled.

Remote control of the instrument can also be initiated from the control computer with the REN command in conjunction with addressing as LISTENER, e.g. with the statement

```
REMOTE 702
```

The LOCAL key can be rendered inoperative to guard against accidental operation if the LLO command follows the REN command. This is done by programming

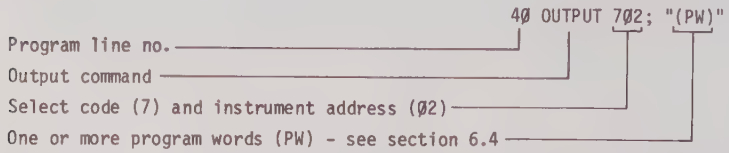
```
LOCAL LOCKOUT 7
```

The LLO command is cleared and manual control is restored with the GTL command (see also IEC bus brochure), which is effected by the statement

```
LOCAL 702
```

6.3.2.2 Setting up the instrument using program data

Once the instrument has been set up by clearing the interface, resetting to the basic settings (see section 6.4.2) and remote enable, the instrument can be programmed with statements of the form:


40 OUTPUT 702; "(PW)"
Program line no.
Output command
Select code (7) and instrument address (02)
One or more program words (PW) - see section 6.4

The program words (PW) consist of a HEADER followed by a decimal number and are always concluded with a comma. Each PW corresponds to a specific function of the instrument. All the program words are listed in logical order in table 6-3, and described in alphabetical order in section 6.4.3.

It is possible to put several PWs, each separated by a comma, into the output data string. The order in which the data is processed internally by the PS-15 is: generator mode ("G...,"), impedance, level, frequency.
Thus, for example, steps 5 to 7 in table 6-2 could also be entered as follows:

```
OUTPUT 702; "G00, L-0008.5, F00250400, T2,"
```

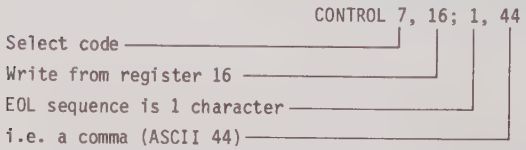
NOTES about the comma:

Every PW must end with a comma. If this is not done and, for example, the following is programmed:

```
(a)  40 OUTPUT 702; "T1, P4"                    comma missing
                :
     70 OUTPUT 702; "F00123000,"                or
(b)  70 OUTPUT 702; "T1, P4 F00123000,"         !comma missing
```

then in both cases, the PW "P4" will not be executed until the computer encounters the next comma, i.e. after the PW "F00123000," (in line 70). However, the frequency setting f = 123 kHz will be lost!

Errors of type (a) can be avoided by programming the HP-85 EOL (end of line) sequence to automatically include a comma. This is done by writing the statement to alter IEC bus registers 16 and 17 of the HP-85:



The normal EOL sequence of CR and LF which may be required by other instruments is restored by:

```
CONTROL 7, 16; 2, 13, 10      (normal EOL sequence)
```

There is no corresponding corrective measure that can be taken to avoid errors of type (b).

6.3.2.3 Reducing program data transmission times

A character string of 21 characters is always output by the HP-85 to the instrument for transmitting programming data. If the PW "JF+,", (i.e. a short string) is entered as the statement

```
8Ø OUTPUT 7Ø2 ; "JF+,"
```

the string will be extended automatically to 21 characters with spaces. This results in a longer than necessary transmission time of approx. 185 ms with the PS-15 in TØ trigger mode. In general, it is preferable that the commands be executed in the shortest possible time (controller processing, transmission and setting).

The output of spaces is suppressed by the use of the K format command; the time required for the example is reduced by

(21-4) • 0.80 ms +1 ms = 14.6 ms,

resulting in a time of approx. 170 ms for execution of the command statement:

```
8Ø OUTPUT 7Ø2 USING "K" ; "JF+,"
```

If the commands which are automatically sent when the OUTPUT command is entered are written out in full, the transmission time can also be reduced:

```
(a)                          SEND 7 ; MTA   UNL LISTEN 2 DATA "JF+," or
                                        |   |    |
(b)                          SEND 7 ; CMD "U?" & CHR$ (34) DATA "JF+,"
Select code ----------------------------|   |    |          |
IEC bus command (ATN = 1) --------------|   |    |          |
My talk address (HP-85) 21 -------------|   |    |          |      - CHR$ (21 + 64) = 'U'
Unlisten -------------------------------|   |    |          |
Listen address group (PS-15) Ø2 ------------|    |          |      - CHR$ (Ø2 + 32) = '"'
Programming data (ATN = Ø, false): ---------|    |          |
                                                 |          |
                                                 |          |
```

Execution time: 148 ms (example b)

6.3.2.4 Abbreviation of program words

An example for reducing the execution time was described in the last section. If the symbol "+" (= + ve step) in line 8Ø is also omitted, the time will be reduced by a further 1 ms. However, if the "+" is to be omitted, then the "JF+," command must have previously been programmed.

With all the other PWs, such as that used for inputting the frequency, it is possible to use an abbreviated form to save time; only those sections of a previously programmed PW which are to be altered need to be written. Leading zeroes must, therefore always be entered.

Example: 1st frequency is 2.345 000 MHz,
2nd frequency is 2.445 000 MHz (100 kHz higher)

Programming:

```
13Ø  OUTPUT 7Ø2 ; "FØ2345ØØØ,"
 :
 :
18Ø  OUTPUT 7Ø2 ; "FØ24,"
```

Note:

The programmer must always be aware of the functions which have been set previously if this abbreviated method of entering commands is used.

6.3.2.5 Continuous and single triggering "TØ," and "T1,"

Steps 5 and 6 in table 6-2 of the familiarisation program for the PS-15 (PWs "G ...,", "L ...," and "F...,") where executed immediately the command had been entered, i.e. as soon as the END LINE key was pressed. In this way, the operation resembles manual mode: changes in instrument settings are carried out immediately without the need for an additional trigger command. This corresponds to the "continuous" trigger mode which is set with the basic setting (see 6.4.2) or with the PW "TØ,".

In "single" trigger mode, functions which have been entered are not executed until the additional trigger command is received. The PW "T1," switches the instrument to "single" trigger mode. The BASIC statement:

```
TRIGGER 7Ø2
```

causes the controller to send the IEC bus command GET (GROUP EXECUTE TRIGGER) to the instrument (with address Ø2).

6.3.2.6 Waiting for settings to be completed (STATUSBYTE, SERVICE REQUEST)

A wait period must be provided between the computer triggering the level generator and the calling up of the setting data (e.g. level and frequency). Incorrect data will be called up from the generator (and possibly the receiver) if the ENTER command follows immediately after the TRIGGER command in the control program (see table 6-2, nos. 9 and 10). The four different methods of providing this wait period are detailed below.

1a) Use of the WAIT statement

If the wait time is approximately constant and is known (say, 200 msec), then the statement

```
WAIT 2ØØ
```

will suffice to make the HP-85 wait until the programmed setting has been completed (in the example in table 6-2, this statement could be inserted between 9 and 10). This wait period can also take account of the settling time of the generator (approx. 70 msec). If the wait period is unknown or is variable, the end of the wait period can be recognised automatically by repeated interrogation of the BUSY bit in the status byte or of the SRQ (SERVICE REQUEST) line, or with a SRQ interrupt from the controller.

1b) Serial poll

The instrument responds to a serial poll from the controller by sending the status byte (see 6.4.5); the controller evaluates the BUSY bit (normally bit 5 with weighting $2^4 = 16$). A SRQ is not necessary.

The command in HP-85 BASIC is: (see 1b, 6.3.3.1):

```
23Ø  S = SPOLL (7Ø2)                    Serial poll of instrument with address Ø2
24Ø  IF  BIT (S,4) THEN 23Ø
```

This loop will operate until the BUSY bit (true = 1) which is set by the TRIGGER command is reset at the end of the measurement (false = 0); i.e. the controller waits until the data is ready.

Other bits present in the status byte can be used for signalling errors or incorrect evaluation; their meanings and coding are described in 6.4.5.

If this continuous serial poll (each SPOLL is approx. 15 ms using the HP-85) leads to corruption of sensitive level measurements or interference on other instruments, this effect can be tempered by inserting a WAIT period greater than 50 ms.

1c) Repetitive SRQ interrogation

If there is no continuous data traffic on the IEC bus, the third possibility for determining the completion of the setting is by repeated interrogation of the IEC bus control lines, particularly the SRQ line of the controller interface (see 1c, 6.3.3.1 for example using HP-85):

```
23Ø STATUS 7, 2; Q                    IEC control line interrogation
24Ø IF NOT BIT (Q,5) THEN 23Ø         Evaluation of RQS bit; if no SRQ then repeat
```

The instrument must previously be programmed to issue a SRQ after the setting has been made; this is done when setting up the instrument with the PW "XXØ1,". Lines 23Ø and 24Ø are repeated until the RQS bit in status register 2 (IEC bus control lines) is set.

1d) SRQ Interrupt recognition

Apart from continuous polling of the IEC bus control lines at the controller interface, some controllers can be programmed to jump to a particular point in the program on receipt of a SRQ with statements such as ON INTERRUPT GOTO ... or ON SRQ GOSUB .... Whilst waiting for the SRQ to occur, the controller can be carrying out calculations, etc. (See example 1d for the HP-85 in 6.3.3.1).

If several instruments are connected to the IEC bus, any of which may send out a SRQ in the same period of time, a serial poll of all instruments must also be made to determine which of the instruments has issued a SRQ at the end of a measurement; such instruments will have the RQS bit set (bit 7 = 1) and the BUSY bit will be reset (Bit 5 = 0).

Instead of a serial poll, a parallel poll of all the instruments (up to a max. of 8) can be used to determine this more rapidly. This is possible if the instrument is programmed to issue a SRQ after the setting has been made (PW: "XX...," e.g. "XXØ1Ø1,").

The command for this in HP-85 BASIC is:

```
A = PPOLL (7)
```

The variable, A, is the value of the individual bits on lines DIO 1 to DIO 8. If, for example, the status bits DIO 1 and DIO 3 are set, A = 5 ($2^0 + 2^2$). The instrument thus identified will then be serial polled to determine the reason for the SRQ from the status byte.

6.3.2.7 Calling up the settings and error messages

Once the instrument has been addressed as TALKER, the controller can call up the measurement data (i.e. settings such as level and frequency, and error data) from the PS-15; this data can be used for further processing. This procedure is realised using the HP-85 with the statement: (see also program example, table 6-2, no. 10)

```
ENTER 7Ø2  USING "%,%K"; A$
```

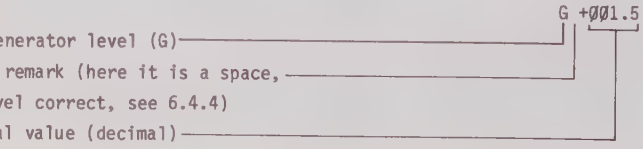
ENTER 7Ø2 addresses the instrument (address Ø2) as talker[1]. The format specification which follows, "%,%K" (see also HP-85 I/O programming guide) enables the controller to recognise EOI and LF as denoting the end of a line. In place of the first "%," it is also possible to write "#," (no LF required at end of line).

---

1) see note on talker function at the end of this section

The type of data which is stored in the form of a string variable (in the example A$), and which will be printed out with the command PRINT A$ or displayed on the screen with the command DISP A$, depends on the measuring mode that has been programmed; this immediately precedes the data.

In the example of table 6-2, the instrument was set to "D1," that is "generator level" as it was reset to the basic settings. Only the level is output in the following format:



The units (such as Hz, dB, dBm, etc.) are not output; these are easily seen from the programming.

If the measurement data was assigned to a numerical variable (see 10 in table 6-2), the value can be further processed without any problems, but the information contained in the first two (alphabetical) characters will be lost.

If error evaluation which is made from the second alphabetical character is required (special remark), then the statement:

```
ENTER 7Ø2 USING "%,X,A,K" ; E$,LØ
```

is used.

E$ then corresponds to a space if all conditions were correct (see 6.4.4). LØ is the numerical value of the level.

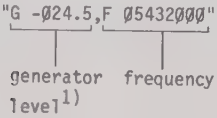
The output format for the measurement data is not always just one word. For example, the output for "D3," consists of two words (output level and frequency); each word is separated by a comma.

These two words can either be assigned to
a) a single string variable, or
b) each single word to a string and/or numeric variable.

Example a)

As the string length is more than 18 characters long, (19 in this example), the minimum string length must be set for the HP-85 controller with a DIM statement. (In the example, 20 characters are set.)

```
1Ø DIM L$[20]
2Ø S2=7Ø2
3Ø REMOTE S2
4Ø CLEAR S2
5Ø OUTPUT S2 ;"GØØ,L-Ø24.5,FØ5432,D3,T1"
6Ø TRIGGER S2
7Ø WAIT 2ØØ
8Ø ENTER S2 USING "%,%K" ; L$
9Ø DISP L$
1ØØ END
gives:
L$="G -Ø24.5,F Ø5432ØØØ"
```



1) The generator level set will be stored even if the generator is blanked.

After the data has been called up (line 8Ø), the numerical values of the data can be determined using BASIC statements.

Note on line 7Ø:

More elegant ways of providing a wait period between the trigger (line 6Ø) and the end of the measurement (line 8Ø), are discussed in 6.3.2.6.

Example b):

Replace line 8Ø in the previous example with:

- Assignment of 2 string variables:

```
8Ø ENTER S2 USING "%,8A,X,1OA,X,%K" ; L$,F$
This gives: L$ ="G -Ø24.5",   F$="F Ø5432ØØØ"
```

- Assignment of 2 numerical variables without error evaluation:

```
8Ø ENTER S2 USING "%,K" ; LØ,FØ
gives: LØ = -24.5                    and FØ = 5432ØØØ
```

- Assignment of 2 string and 2 numerical variables for error evaluation:

```
8Ø ENTER S2 USING "%,X,A,K" ; E1$,LØ,E2$,FØ
gives the special remarks E1$, E2$ = " " (space)
if the measurement is correct, together with the numerical data
LØ = -24.5 and FØ = 5432ØØØ.
```

Notes on HP-85 formatting specifications:

X	means	Ignore 1 character ("L", "F", in last example); e.g. 4X = 4 spaces
A	means	1 alpha(betical) character (in this case, the 2nd character of the word); e.g. 8A = output 8 characters
K	means	Compact format; numerical values concluded if an alpha character (here: ",") or an EOI occurs
%K	means	String variables of any length concluded by EOI or LF (first example)

Notes on instrument TALKER function:

Before the measurement data is called up, the instrument is addressed as TALKER and the controller as LISTENER (ATN 1 = true). The instrument then transmits the data to the listener with ATN = Ø until the controller concludes the string after receipt of the EOI character, which normally results in bus traffic being blocked. ATN remains Ø (= untrue), however, hence the talker function remains active. This blocking function of the controller is prevented when another instrument on the bus, such as a mass memory or a VDU, is addressed as talker at the same time. The PS-15 will therefore continue to transmit data (CONTINUOUS TALKER). If this causes problems (e.g. if bus extenders are used or the other instruments addressed as listener cannot function correctly), this can be rapidly stopped by a "harmless" IEC command, such as UNLISTEN (ATN = 1). The BASIC program then reads:

```
7Ø ENTER 7Ø2 USING "%,%K" ; A$
71 SEND 7 ; UNL
```

Line 71 can be omitted, of course, if the IEC commands such as OUTPUT 7Ø2 ... or TRIGGER 7Ø2 follow immediately after the ENTER statement.

Notes on error messages:

As stated above, the special remark character can be checked to see if the data output was error-free.

The error number is always 0 unless the special remark character is "E" or if bit 6 of the status byte is logic "1" (see 6.4.5) - see also under measurement data codes "E". To call up the error number, the following statements are used:

```
90  OUTPUT 702 ; "D9,"              selects instrument output data (i.e., error
                                    message)
100 ENTER 702 USING "%,%K" ; E$     call up error number
110 OUTPUT 702 ; "D3,"              reselect instrument output
                                    data
120 PRINT E$                        error number output
```

As a result of this, the error number will be displayed, e.g. EE4631

- word code character E (ERROR)
- special remark code (program error)
- type of error (syntax error)
- error note (frequency, position 1, see table 6-5)

6.3.3 PS-15 PROGRAMMING: SOME EXAMPLES

The examples given here are intended to demonstrate the behaviour of the instrument when a controller and the PS-15 only are connected to the bus. These examples, however, can be incorporated into the BASIC programming of larger measurement systems with several instruments if certain amendments are made.

6.3.3.1 Waiting for a setting to be completed

Let us assume that a particular output level is to be set and the value displayed on the VDU of the HP-85 (similar to the example in table 6-2).

As noted in 6.3.2.6, the controller must WAIT between the TRIGGER ... and ENTER ... statements until the setting (no settling time) has been made. In the examples, this occurs in line 230 or lines 230 to 240. The examples are:

1a) constant WAIT time,
1b) repetitive evaluation of the BUSY bit of the status byte,
1c) repetitive polling of the SRQ line, and
1d) by recognition of an SRQ interrupt by the controller.

For the sake of clarity, only example 1a has been written out completely. The lines written out for examples 1b to 1d are simply substituted in 1a to give the complete programs for these examples.

If several instruments can issue an SRQ, examples 1c and 1d must be altered to include a serial poll (e.g. in line 241) of all instruments to establish which of them has issued a service request.

Examples 1a to 1d: Programming the SPM-15 using the HP-85:

Problem: Setting an output level (e.g. -15.5 dBm) following by output of the setting data (measurement data).

Showing: Wait period between TRIGGER... and ENTER...

1a) Use of the WAIT statement

```
1Ø ABORTIO 7                          ! 1Ø: Interface clear (IFC) and remote enable (REN)
15 !
2Ø S2=7Ø2                             ! 2Ø: HP-85 select code 7 and IEC bus address Ø2 of the
                                      !     PS-15
3Ø CLEAR S2                           ! 3Ø: PS-15 basic setting (see 6.4.2)
4Ø OUTPUT S2 ;"T1,"                   ! 4Ø: T1: required for TRIGGER... and ENTER...
5Ø !
6Ø OUTPUT S2 ;"GØØ,L-Ø15.5,"          ! 6Ø: Setting: generator on, level -15.5 dBm
7Ø !
21Ø TRIGGER S2                        ! 21Ø: Triggering of setting
22Ø !
23Ø WAIT 2ØØ                          ! 23Ø: wait period (e.g. 200 ms) for setting of level and
                                      !      setting time.
24Ø !
25Ø ENTER S2 USING "%,%K" ; G1        ! 25Ø: Call up level when END message on EOI line, assign
                                      !      level to a variable
26Ø DISP "Level/dBm=";G1              ! 26Ø: screen display of level.
27Ø END
```

Note on line 25Ø: USING "%,%K" enables the HP-85 to recognise the END message (sent simultaneously with the last byte from the PS-15) as signalling the end of a data set. (EOI line). See also 6.3.2.7 and HP-85 operating manual (HP/IO programming guide, section 3).

Substitute the following lines in example 1a):

1b) Repetitive evaluation of BUSY bit in status byte (SERIAL POLL)

```
23Ø S=SPOLL(S2)                       ! b) status byte poll
24Ø IF BIT(S,4) THEN 23Ø              ! b) bit evaluation, if BUSY = true, then repeat
```

1c) Repetitive poll of SRQ line of HP-85 (HP-IB) interface

```
4Ø OUTPUT S2 ;"T1,XXØ1Ø1,"            ! c) XX: instrument issues SRQ at end of measurement
23Ø STATUS 7,2 ; Q                    ! c) poll of IEC bus control lines
24Ø IF NOT BIT(Q,5) THEN 23Ø          ! c) SRQ evaluation; if no SRQ, then repeat
```

1d) Controller automatically recognises SRQ interrupt

```
4Ø OUTPUT S2 ;"T1,XXØ1Ø1,"            ! d) XX: instrument issues SRQ at end of measurement
5Ø ON INTR 7 GOTO 24Ø                 ! d) if SRQ issued, call up measured level
23Ø ENABLE INTR 7;8                   ! d) react to SRQ only
231 GOTO 231                          ! d) HP-85 waits for SRQ interrupt
24Ø STATUS 7,1 ; S1                   ! d) HP-85's interrupt register cleared
```

When the program has finished running, the screen display will show:

Level/dBm = -15.5

for example.

6.4 DEVICE DEPENDENT MESSAGES

6.4.1 PROGRAM- AND MEASUREMENT DATA OVERVIEW

Table 6-3 contains the programming data arranged logically according to function; it shows the format of this data. Programming data can consist of one or more program words (PW), each of which consists of a code, a decimal number or the + or - sign, and finally a comma.

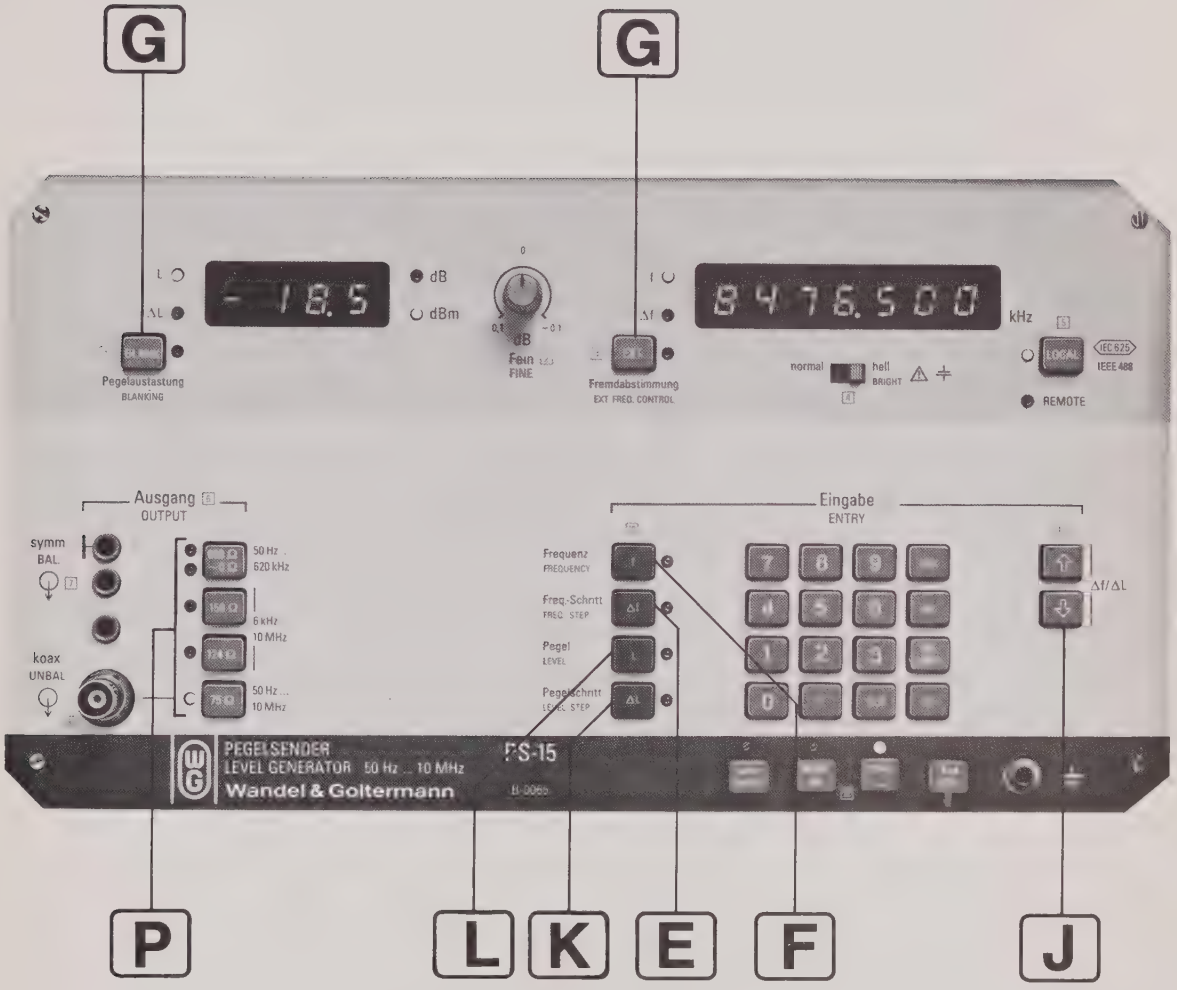
The PW code consists of one or two letters (e.g. P = output impedance, XX = SRQ and transmission mode, etc.).

The PWs required can easily be assembled from the PW codes and the information (arranged alphabetically) in section 6.4.3.

Table 6-4 shows the format of the measurement data. Measurement data in this case consists of generator level and frequency as well as the error number. The individual "words" of the measurement data consist of a code, a remarks code, a decimal number, and a closing character (see footnote 3, table 6-4). A detailed description of the measurement data is arranged alphabetically in section 6.4.4.

Figure 6-5 shows the instrument functions and the corresponding PW codes; this will help you to find the PW required very quickly in section 6.4.3.

The words for programming data and measurement data which are used for the PS-15 are, to a large extent, the same as those used for the PS-19. This means that programs for one instrument can be readily adapted to suit the other instrument.



JF = Frequency

JL = Level

Figure 6-5 Program word codes related to the controls of the PS-15 Level Generator

Instrument function (controller to PS-15)	Program word (PW)	
	HEADER Word code	BODY & CLOSING CHARACTER Decimal number & comma[1]
Data traffic		
- SRQ (service request) and transmission mode	XX	4d,
- trigger mode	T	d,
- data output selection (e.g. results; for measurement data word codes, see table 6-4)	D	2d,
Generator functions		
- Level blanking off/on	G	2d,
- Remote tuning off/on	G	2d,
- Frequency step positive/negative ⇧⇩	JF	+,
- Level step positive/negative ⇧⇩	JL	+,
- Output impedance	P	d,
Frequency settings		
- frequency f	F	8d,
- step width Δf	E	8d.
Generator level setting		
- generator level L	L	+3d.d,
- Step width ΔL	K	2d.d,

1) d corresponds to a decimal number, thus 4d means a four-digit decimal number. Only the + or - signs are used with program words "JF" or "JL".

Table 6-3 Instrument functions and their corresponding program words (instrument programming data)

Function set, error message (from SPM-15 to controller)	HEADER Word code	Remarks[1] code	BODY AND CLOSING CHARACTER Decimal no.[2] and pre-programmed closing char.[3]
Frequency in Hz	F	a	8d
Generator level in dB(m)	G	a	+3d.d
Error number	E	a	4d

1) a is either a space or a capital letter
2) d corresponds to a decimal number
3) The output format of the measurement data may consist of one or more words (see under program word "D...,"); each word is, however, separated from the next by a comma. The closing character set with program word "XX...," will only be transmitted at the end of the measurement data: the message END will be placed on the EOI line and/or the ISO 7 bit code LF will be sent.

Table 6-4 Measurement data format (instrument output data)

6.4.2 BASIC INSTRUMENT SETTINGS

The instrument is reset to a defined set of output conditions (known as the basic setting) when the IEC bus commands DCL (device clear) or SDC (specific device clear), and also after IFC (interface clear) if the CLR wire link is fitted (see figure 6-2). This basic setting will also be made at switch-on if the instrument has previously been switched off at the mains (see 3.5) or if "CLR" is pressed during switch-on.

The basic setting corresponds to the following set of program words (cf. 6.4.3):

PS-15 LEVEL GENERATOR:

XXØØØ1,	SRQ and transmission mode: No SRQ, no parity bit, EOI with last data byte
TØ,	Trigger mode: continuous
G1Ø,	Generator output blanked, external tuning off
PØ,	Output impedance 75 Ω, coaxial
FØØ1ØØØØØ,	Frequency f = 100 kHz
EØØØ1ØØØØ,	Frequency step width Δf = 10 kHz
L-ØØ1.Ø,	Generator level L = -1 dBm or -10 dB (L-1Ø.Ø)
KØ1.Ø,	Level step width ΔL = 1 dB

Figure 6-6 Basic settings of the PS-15 level generator

6.4.3 ALPHABETICAL LISTING OF PROGRAM WORDS FOR THE PS-15

The word codes are listed in alphabetical order in this section. Together with the list of possible settings (see figure 6-7 for example), any PW required can easily be formed. The heading of the table gives the meaning of the PW code, and in the last line of each table the standard setting of the particular parameter is listed. Text between [square brackets] corresponds to the keyboard lettering. Symbols used in the text (such as ΔL level step) are the same as those printed on the front panel of the instrument.

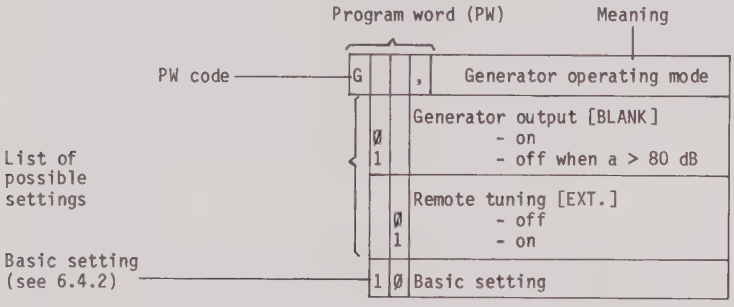
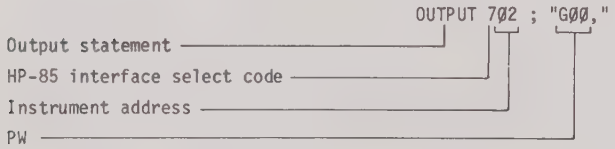


Figure 6-7 Formation of a program word

To form a PW, select the setting from the list of possible settings and enter the number or group of numbers in the same order as they are given in the table, with the PW code first. The PW must be completed with a comma. Under some circumstances, the PW can be abbreviated; this method will speed up the transmission time (see PW code F, frequency setting). Leading zeros must, however, always be entered.

The program examples in this section refer to the HP-85 controller with interface select code "7" and instrument address "Ø2".

Program example: Switching off the generator blanking function and operating with external tuning facility switched off. From figure 6-7, the program statement for this is:



Note:

1. If transmission times for the HP-85 are to be shortened, the shortened format can be selected with the "K" command (see 6.3.2.3):

```
OUTPUT 7Ø2 USING "K" ; "GØØ,"
```

2. In the above example, the PW could also be "GØ," if the setting for remote tuning (2nd. number) is not to be altered.

D

D		,	Data output selection
	1		- generator level
	2		- current frequency
	3		- generator level and frequency
	9		Error number

The output format of the data consists of one (e.g. when "D1," is selected) or more (when "D3," is selected) words. A comma is placed between each word, but at the end of the data string only the closing character which is determined by the transmission mode (PW code XX) will be transmitted.

Table 6-4 shows how the measurement data from the PS-15 to the controller is formed; a more detailed description, listed alphabetically, is found in 6.4.4.

Error message:

Number	Cause (X)	Automatic correction
4-431	DX	D1

E

E				,	Frequency step [Δf] in Hz
	Ø Ø	Ø 1 Ø	Ø Ø Ø	Basic setting	1Ø kHz
	MHz	kHz	Hz		

The leading zero (10 MHz position) must always be entered to preserve compatibility with existing programs for the PS/SPM-19 and SPM-15.

Additional programming:

- F for frequency f

Error messages:

Number	Cause (X)	Automatic correction
2-11Ø	Ext. frequency tuning	ΔF value not accepted
4-531	EX.....	1st digit = Ø
4-54-	E.XXXXXXX	Incorrect digit = Ø

F				,	Frequency f in Hz
	Ø Ø	1 Ø Ø	Ø Ø Ø	Basic setting	100 kHz
	MHz	kHz	Hz		

The zero in the 10 MHz position must always be programmed to preserve compatibility with PS/SPM-19 or SPM-15 programs.

If external frequency tuning is set (PW "GX1,") frequency settings cannot be made otherwise error number 2-11Ø will be displayed.

The frequency setting is limited to 999.999 kHz if the output impedance is 600 Ω or ≈ 0 Ω.

Additional programming:

- E for frequency step

Note for shortened programming:

If only the first part of the program word plus a comma is transmitted instead of the complete PW, then the only part of the PW that will be altered is the digit positions corresponding to the new input values. The remaining digits will retain their previous values.

Example:
Frequency output "FØØ1ØØØØ5,": first measurement at 100.005 kHz,
Frequency output "FØØ2,": next measurement at 200.005 kHz.

Error messages:

Number	Cause (X)	Automatic correction
2-1Ø1	Frequency change due to change of impedance	Upper frequency limit
2-11Ø	Ext. frequency tuning	F value not accepted
4-631	FX.....	1st position = Ø
4-64-	F.XXXXXXX	Incorrect position = Ø

G

G			,	Generator operating mode
	Ø			Generator output [BLANK] - on 1 - blanking when a > 80 dB
		Ø		Remote tuning [EXT.] - off 1 - on
	1	Ø		Basic setting

When the frequency is changed, the generator output is not blanked automatically.

Error messages:

Number	Cause (X)	Automatic correction
4-731	GX.	Generator blanked
4-732	G.X	Remote tuning off

J

J			,	Frequency or level step
				Frequency step
	F	+		- positive ⇧
	F	-		- negative ⇩
				Level step
	L	+		- positive ⇧
	L	-		- negative ⇩
				Basic setting
	F	+		- frequency
	L	+		- level

If the step direction (+ or -) has previously been programmed, the "+" or "-" character can be omitted (see 6.3.2.4); the programming will then be "JF," or "JL,".

If external frequency tuning is set, frequency settings cannot be made otherwise error message 2-11Ø will be displayed.

Additional programming:

- E for frequency step or
- K for level step

Error messages:

Number	Cause (X)	Automatic correction
2-11Ø	Ext. frequency tuning	F value not accepted
4-L31	JX.	JL.
4-L32	JLX	JL+

K			.		,	Level step ΔL in dB
	Ø	1	.	Ø		Basic setting

K

No sign is required when inputting the level step value

Additional programming:

- L for generator level

Error messages:

Number	Cause (X)	Automatic correction
4-H31	KX...	1st position = Ø
4-H4-	K.XXX	Incorrect position = Ø

L	+	Ø	X	Y	.	Z	,	Generator level in dB or dBm
	-	Ø	Ø	1	.	Ø		Basic setting[1)]

L

For accurate level setting, the "fine" potentiometer [2] must be set to the mid-point 0.

The level settings are absolute and always take account of the setting of switch [31] on the back panel.
If a level is entered which lies outside the range limits, the corresponding limit value will be set.
The input must always have 3 places before the decimal point to preserve compatibility with PS-19 programming.

Error messages:

Number	Cause (X)	Automatic correction
2-2ØØ	Level below lower limit	Lower limit set
2-2Ø1	Level above upper limit	Upper limit set
4-P31	LX.....	Sign "-"
4-P32	L.X....	2nd position = Ø
4-P4-	L..XXXX	Incorrect position = Ø

1) for dBm setting; -Ø1Ø.Ø for dB setting

P

P	,	Output impedance
	Ø	- coaxial 50 Hz ... 10 MHz - Z_o = 75 Ω; $Z_{OUT} = Z_o$
	1	- balanced I 6 kHz ... 10 MHz - Z_o = 124 Ω; $Z_{OUT} = Z_o$
	2	- Z_o = 150 Ω; $Z_{OUT} = Z_o$
	3	- balanced II 50 Hz ... 620 kHz - Z_o = 600 Ω; Z_{OUT} = 0
	4	- Z_o = 600 Ω; $Z_{OUT} = Z_o$
	Ø	Basic setting

Each impedance setting has specific output level limits. If the impedance is changed, the level will be set according to the new limits, which may lead to a change in output level (see 1.2.4).

If "P3," and "P4," is selected, the frequency is limited to 999,999 kHz. If the previous frequency setting was higher than this, the limit value will be set if the impedance is changed.

Error messages:

Number	Cause (X)	Automatic correction
2-2ØØ	Level below lower limit	Lower limit set
2-2Ø1	Level above upper limit	Upper limit set
2-1Ø1	Frequency limit	f = 999.999 kHz
5-Ø31	PX	PØ

T

T	,	Trigger mode (continuous or single)
	Ø	continuous triggering of measurements; instrument is set immediately after receipt of program data
	1	single trigger; IEC GET command (Group Execute Trigger) required to set instrument and call up result
	Ø	Basic setting

Error message:

Number	Cause (X)	Automatic correction
5-431	TX	TØ

XX

X X				,	SRQ and transmission mode
Ø 1					SRQ at switch-on or restoration of mains power - no - yes
	Ø 1				SRQ on completion of setting - no - yes
		Ø 1 2			Character transmission in ISO 7 bit code - without parity bit - with odd parity bit - with even parity bit
			Ø 1 2 3		EOT character (PS-15 data output) - no EOT character - END set on EOI line with last data byte - END set and ISO 7 bit code ETX sent - ISO 7 bit code ETX sent
Ø	Ø	Ø	1		Basic setting

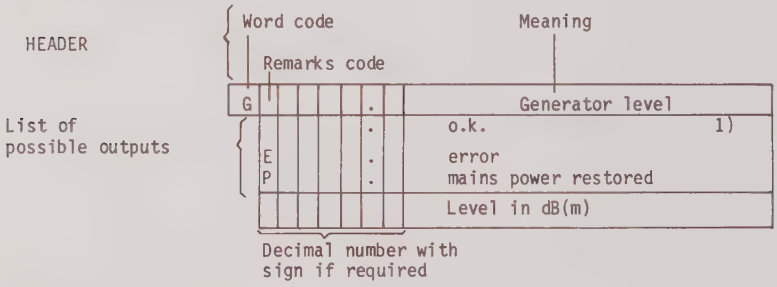
6.4.4 MEASUREMENT DATA (GENERATOR LEVEL; FREQUENCY; ERROR MESSAGES): ALPHABETICAL LISTING

The measurement data consists of a two character HEADER (word code and remarks code), a decimal number with sign (if required) followed by a decimal point and the closing character.
The word code identifies the type of measurement data (e.g. the physical value of the generator frequency, F). The remarks code indicates the conditions in force at the time of measurement.
Figure 6-8 summarises the PS-15 remarks code characters and their meanings.

Remarks code	Meaning
E	Error: Operator- or syntax error
P	Power on: appears with first set of data after switch on or restoration of mains power if SDC or DCL not set by controller.

Figure 6-8 Remarks codes and their meanings

The closing character sent by the instrument (END on the EOI line and /or ISO 7 bit code ETX) is determined by the PW code "XX...,". The ISO codes for CR or LF are not transmitted. The units of the measurement data (such as Hz, dB, dBm, etc.) are not transmitted, but can be derived from the programming.



1) The remarks code is a space

Figure 6-9 Measurement data format

The PW "D..," determines which measurement parameters (i.e. generator level, generator frequency and/or error messages) will be called up as measurement data by the controller (see 6.4.3).

Example of measurement data: (in this case generator level):

(compare section 6.3.2.7)
ENTER 7Ø2 USING "%,%K" ; A$

PRINT A$ gives: GE -Ø12.3
Word code: Level (G)
Remarks code: error (E)
Numerical value: (decimal number)

E

E	Error
P	First result since power on - no 1) - yes
2 4 5	Error class operator error syntax error syntax error

Error numbers:

2-1ØØ - lower frequency limit
2-1Ø1 - upper frequency limit
2-11Ø - external frequency tuning on
2-2ØØ - output level too high
2-2Ø1 - output level too low

Error numbers class 4 and 5, which refer to program words (syntax error), are found in section 6.4.6.1 and table 6-5, together with notes on the correction of such errors.

F

F	Generator frequency in Hz
E P	o.k. 1) error first result since power on

MHz | kHz | Hz

G

G	.	Generator level in dB(m)
E P	. . .	o.k. 1) error first measurement since power on

1) The remarks code is a space

6.4.5 PS-15 STATUS BYTE

As well as the measurement data (see 6.4.4) the status data of the instrument can be recalled at any time via the status byte (STB) by means of a SERIAL POLL (SPOLL). Figure 6-10 shows the assignments of the IEC bus data lines DIO 1 to 8 and the meanings attatched to these assigned values. Some manufacturers number the data lines from Ø to 7; this should be taken into account when it is necessary to evaluate a particular bit (1 = true, 0 = false).

Status Byte:	Independent of instrument			Dependent on instrument (includes bit 8)			
	RQS	ERROR	BUSY				
Line Bit	DIO 8 8	DIO 7 7	DIO 6 6	DIO 5 5	DIO 4 4	DIO 3 3	DIO 2 2	DIO 1 1
Value	2^7 128	2^6 64	2^5 32	2^4 16	2^3 8	2^2 4	2^1 2	2^0 1

Figure 6-10 Status bit assignments on the IEC bus data lines

The coding of the bits which are independent of the instrument follows the norm prescribed in DIN IEC 625-2 or IEEE 728.

The RQS bit is true (= 1) when the instrument issues a SRQ on the SRQ line. The SRQ line is reset (= 0) by the SPOLL. The RQS bit is only reset (0 = false) when the instrument is re-addressed via the bus, which may be in one of the following ways:

- data input as LISTENER,
- data output as TALKER,
- GET trigger command received,
- DCL or SDC commands received,
- switching from REMOTE to LOCAL and vice versa, and
- a further SPOLL

(see also IEC bus brochure).

The ERROR bit (DIO 6) is reset at

- power on
- triggering of a new measurement
- transmission from a trigger mode

BUSY bit (DIO 5):

In "single" trigger mode, the BUSY bit is set during the processing of the setting instruction(s), and reset when this process is completed. This means that the end of the instrument function program, and hence the point at which valid measurement data is available, can be determined exactly by polling the BUSY bit.

MAINS ERROR bit (DIO 4)

This bit is set to 1 if a power supply failure has occured and power has subsequently been restored.
The bit is reset when

- instrument is addressed as LISTENER
- instrument is addressed as TALKER
- DCL or SDC commands received
- IFC command received

STATUS BYTE (STB)								Bit designations
Ø 1								REMOTE LOCAL — LOCAL bit
	Ø 1							RQS - no - yes — RQS bit
		Ø 1						Error - no — ERROR bit - yes
			Ø 1					Measurement 1) - ready - busy
				Ø 1				Mains power restoration 1) - no - yes
								not used
					1 Ø	Ø 1		Generator operation in - dB - dBm
8 128	7 64	6 32	5 16	4 8	3 4	2 2	1 1	Bit or DIO line 2) Value

1) SRQ possible, see PW code "XX...,"

2) Numbered to DIN standards (IEC 625).
Most controllers number the bits from Ø to 7, i.e. the exponent of the value ($2^0 = 1$, $2^1 = 2$, ...$2^7 = 128$). The lines DIO 8 to DIO 1 are therefore addressed internally with bits 7 to Ø.

During REMOTE operation, the front panel controls of the PS-15 are disabled with the exception of the LOCAL key (cf. 6.3.2.1).

6.4.6 GENERAL INFORMATION

6.4.6.1 Correcting incorrectly entered program words (Error types 4 and 5)

The additional error numbers which are given in table 6-5 refer to program words which have been entered incorrectly (syntax errors), and they indicate how the error can be corrected by the operator. The error messages appear on the frequency display of the PS-15 (refer to column 1 of table 6-5) and are present on the IEC bus data lines when the controller calls up the data (refer to column 2, table 6-5).

Example 1:

The level is to be increased by a particular level step value.
The correct program word for this is "JL+,".

```
10 REMOTE 7
20 CLEAR 702
30 OUTPUT 702 ;"J+,D9,"  <-- Programming error, "J+," entered by mistake
40 ENTER 702 USING "%,%K" ; A$
50 WAIT 200
60 DISP A$
70 END

EE4A31  <-- Error message displayed on screen
```

As a result of the incorrect PW ("J+,"), the following error message will be displayed:

PS-15 frequency display: 4 - L 3 1

HP-85 screen display when programmed accordingly: E E 4 A 3 1

- Word code E ≙ error number
- Special remarks code E ≙ error
- Error message (string) issued by controller when result is read out

Comparison with table 6-5 shows that the error described above concerns the PW code J (3rd. column) and that the error immediately follows the word code (column 4). The instrument selects a value (shown in column 5), so that the program can continue. The error, though, remains displayed. The corrected program word is given in column 6.

When the error has been corrected (here, by entering "JL+,") a level will be displayed corresponding to the last level plus the level step setting. The polling of the error message results in "E ØØØ" being sent to the controller.

Example 2:

A program is to be written to set the following:

Frequency f = 485 kHz, PW "FØØ485," shortened entry!

Level step 5 dB, PW "KØ5.Ø,"

Single trigger mode, PW "T1,"

The program is given below with the numbers:

```
10 REMOTE 7
20 S=702
30 CLEAR S                                  Programming errors:
40 OUTPUT S ;"F00485,K05 0,"  ------------  K05.Ø (instead of KØ5.Ø)
50 OUTPUT S ;"T2,D2,"  ----------------------  T2 (instead of T1)
60 ENTER S USING "%,%K" ; A$
70 DISP A$ @ DISP
80 OUTPUT S ;"D9,"
90 ENTER S USING "%,%K" ; E$
100 DISP E$
110 END
```

```
FE00485000
                                    }  Screen displays
EE5431
```

After the program has been started by pressing RUN, the following error messages will appear (see also table 6-5):

Actions	Display on Screen	Display on PS-15	Error in PW code
Starting the program	FEØØ485ØØØ EE5431	5-431	T
1st correction (input "T1,")	FEØØ485ØØØ EE4B31	4-H31	K
2nd correction (input "KØ5.Ø,")	FØØ485ØØØ EØØØØ	485.000 kHz	no error

The example shows that the last incorrectly entered program word is detected first and shown as an error. In this manner, the programmer can correct the program line by line in reverse numerical order from right to left.

Other error messages (class 0, 1, 2) are found under the heading "Measurement data E" (6.4.4).

Error messages shown on the PS-15 frequency display	Error message expressed as string for reading out by controller	Corresponding PW code	Position in PW where error has occured	Error correction made	Resultant PW or automatic correction
Operator errors:					
2-1ØØ	21ØØ	-	-	-	Lower frequency limit
2-1Ø1	21Ø1	-	-	-	Upper frequency limit
2-11Ø	211Ø	external frequency tuning	-	-	no data transfer
2-2ØØ	22ØØ	-	-	-	Lower level limit
2-2Ø1	22Ø1	-	-	-	Upper level limit
Syntax errors:					
4-431	4431	D	1	1	D1X
4-531	4531	E	1	Ø	EØXXXXXXX
4-54-	454E	E	2..8	Ø	EØXXØXXXX
4-631	4631	F	1	Ø	FØXXXXXXX
4-64-	464E	F	2..8	Ø	FØXXØXXXX
4-731	4731	G	1	1	G1X
4-732	4732	G	2	Ø	GXØ
4-L31	4A31	J	1	L	JLX
4-L32	4A32	J	2	+	JX+
4-H31	4B31	K	1	Ø	KØX.X
4-H4-	4B4E	K	2..4	Ø	KXØ.X
4-P31	4C31	L	1	-	L-XXX.X
4-P32	4C32	L	2	Ø	LXØXX.X
4-P4-	4C4E	L	3..5	Ø	LXXØX.X
5-Ø31	5Ø31	P	1	Ø	PØ
5-431	5431	T	1	Ø	TØ

Note: X is a decimal number (may also include sign, + or -, in PW L position 1).

Table 6-5 Program word error numbers (class 4 and 5 errors)

Notes on the interpretation of error numbers (syntax errors):

1. The first two characters are the ASCII code for the PW code.
   The next two characters are the ASCII code for the error position in the PW.
   Here: 31 (HEX) ≙ 1 (ASCII) position 1
   32 (HEX) ≙ 2 (ASCII) position 2
   4E (HEX) ≙ N (ASCII) nth position (see table 6-5)
2. Error messages are only erased by re-initialisation.
3. If several errors have occured, only the last error is displayed (see 6.4.6.1, 2nd example).

6.4.6.2 Remote control of the PS-15 using the HP 9816 controller

For trouble free operation of the PS-15 from an HP 9816, a minimum cable length of 3 metres is required between the two instruments.

MP MASTER
MA29280

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